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Space

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Cover: The northern edge of Venus' central Alpha Regio captured by Magellan over thirty-six orbits. Image is 600 km wide, elevation varies over 4 km (background); Magellan in Venus mapping orbit (l.); false color perspective of Sif Mons volcano (ctr.); Magellan at Venus (r.).

Courtesy JPL

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Staff

Editor	Tina D. Thompson
Contributors	Roger L. Berg Phillip S. Clark Nicholas L. Johnson H. Kennett Moritz James E. Oberg
Graphics	Karen S. Dow Dana A. Kido Robert E. Shepard
Typesetting	Patrick C. Milligan
Circulation	Stacy B. Fell

Vice President & General Manager **TRW Space & Technology Group**	Daniel S. Goldin
Director, Communications **TRW Space & Technology Group**	Darryl M. Fraser
Vice President, Communications **TRW Space & Defense**	Julian R. Levine

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Skynet

Courtesy British Aerospace

JCSat

Courtesy Hughes Space & Communications

Includes most civil launches; DoD payloads not included. Spacecraft/launch data are listed chronologically. All times listed are Universal (Zulu, GMT) unless otherwise indicated. For additional details, refer to 1990 Summary Log of Space Launches.

Skynet 4A, 4C

The second in a series of UK Ministry of Defence communications satellites was dual-launched with JCSat 2 aboard the the first commercial Titan III at 00:07, January 1. Skynet 4A provides jam-proof communications service between fixed and mobile land and sea-based ground stations. The payload houses one four-channel SHF transponder and one two-channel UHF transponder. An EHF transponder is available for propagation experiments. Built by British Aerospace, the satellite measures 2.1 m by 1.4 m and weighs 1,463 kg at launch. Solar arrays spanning 16 m provide 1,200 W of power. A PAM-2 serving as a third stage boosted Skynet 4A towards its assigned geostationary position at 6 deg e. Skynet 4C, the last of the series, was tandem-launched with the European Eutelsat II aboard an Ariane 44LP at 10:46, August 30. It is stationed above 1 deg. w. Both satellites have a seven-year life expectancy.

JCSat 2

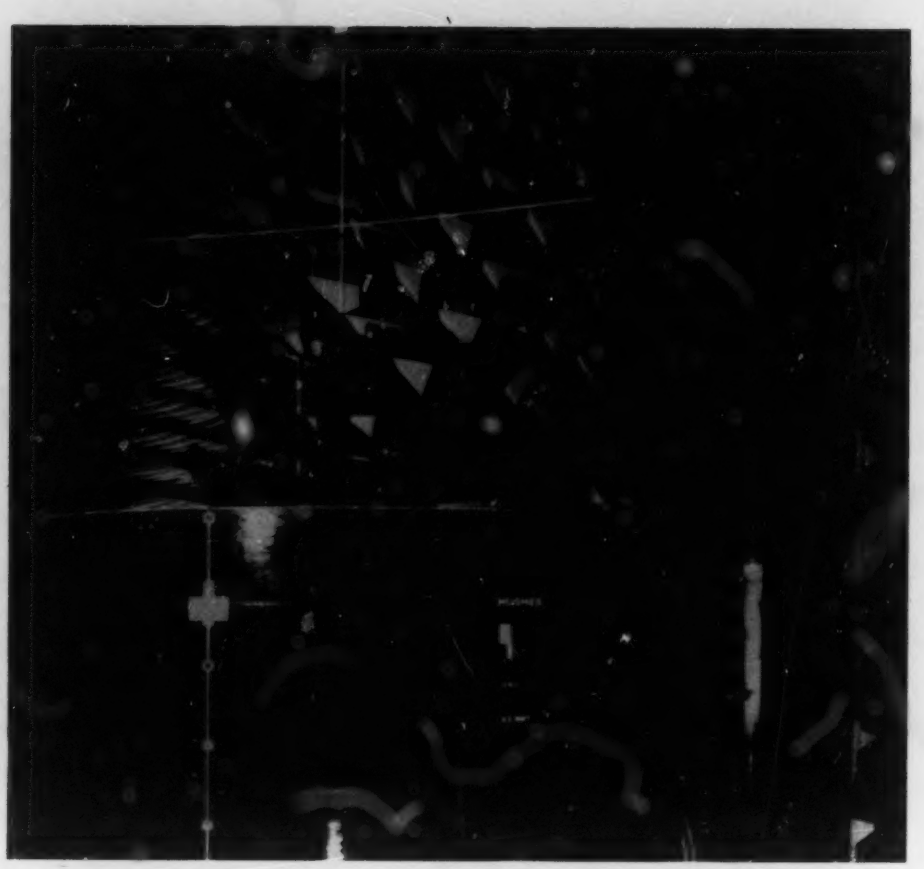
Launched with Skynet 4A aboard the first commercial Titan III, JCSat 2 is the second in a two-satellite series of privately owned high-power Japanese communications satellites. Liftoff commenced at 00:07, January 1. A solid-fuel kick motor boosted the satellite into geosynchronous transfer orbit. The orbit was circularized by a series of liquid-fuel engine firings. After four weeks of tests, the satellite was delivered to its owner/operator, Japan Communications Satellite Company (JCSAT) in February. JCSat is jointly owned by Hughes Communications, Inc., C. Itoh & Co. and Mitsui and Co., Ltd. The satellite provides telephone, TV, facsimile and data services to Japanese businesses. High quality video and message data can be received on user antennas as small as 1.2 m. The Ku-band communications payload provides 32 channels, each able to handle one TV broadcast, 250 telephone circuits or 45 million bits of data per second. One of the Hughes Space and Communications Group's HS 393 series of satellites, JCSat measures 3.7 m by 6.0 m fully extended and with its 2.3-m antenna deployed. It weighed 2,280 kg at launch; 1,364 kg on orbit. Body mounted solar cells provide 2,200 W of power over its 10-year design life. Stationed above 154 deg. e, it joins JCSat 1, launched in March 1989.

STS-32

The shuttle Columbia lifted off on a record 10-day mission to deploy one payload and retrieve another, January 9 at 12:35. Launched from Kennedy Space Center's pad 39A, the 116,271-kg orbiter carried a military communications satellite, six experiments and a five-person crew. Crew members were: Daniel C. Brandenstein, commander; James D. Wetherbee, pilot; Marsha S. Ivins, Bonnie J. Dunbar and G. David Low, mission specialists. Leasat 5 was deployed frisbee-style on orbit 17, 24 hrs, 43 mns into the mission. On day 4, Commander Brandenstein began rendezvous maneuvers to bring Columbia within grappling range of the Long Duration Exposure Facility (LDEF). LDEF, deployed from STS-41C in 1984, was intended to be retrieved by a shuttle flight after 10 months in orbit. The loss of the Challenger and other program delays extended its stay to almost 6 years. Flying within 125 m of the LDEF, Brandenstein fired the orbiter's maneuvering jets and eased Columbia towards the target. At 14:14, with the shuttle in free drift, Bonnie Dunbar directed the RMS end effector to snare the satellite. By 14:30 the capture was complete. After a 4-hr photo session to record the craft's condition, the RMS tucked LDEF into the cargo bay for return to earth. The remainder of STS-32 was spent on materials and biological experiments, and earth photography with the IMAX camera. Columbia touched down on Edwards AFB runway 22 at 09:35, January 20, after 10 days, 21 hrs in space — the longest duration shuttle flight to date. The 9,691-kg LDEF brought shuttle's landing weight to 103,435 kg, another record.

Leasat 5

The last in a series of ultra high frequency Navy communications satellites, Leasat 5 was deployed from STS-32 at 13:19, January 10. Forty-five minutes after ejecting frisbee-style from the cargo bay, Leasat's solid perigee kick motor fired to boost it into transfer orbit. Subsequent solid and liquid-fuel engine firings inserted the satellite into geosynchronous orbit. It reached its assigned station at 177 deg. w, January 14. Leasat 5, also known as Syncom 4, was built by Hughes Space and Communications Group for Hughes Communications, Inc. (HCI). The Navy leases communications service from HCI for DoD users, including air, sea, surface and subsurface units. Twelve UHF repeaters provide the main communications capability; signals are received and transmitted via two helical antennas. Leasat 5 is a 4.26-m-diameter drum, standing 6.17 m high with antenna mast deployed. Designed exclusively for shuttle launch, it weighed 7,711 kg at liftoff, 1,388 kg on orbit. Body mounted solar arrays provide 1,238 W at the end of its 10-year design life.



Leasat *Courtesy Hughes Space & Communications*

SPOT 2

The second French earth observation satellite, SPOT 2, was launched by an Ariane 40, at 01:35, January 22, from Kourou, French Guiana. SPOT 2 was accompanied by six small satellites, making Ariane's first launch of 1990 host to the largest number of payloads for that carrier to date. It was also the first flight of the Ariane 40, an Ariane 44L minus strap-on boosters. The 1,870-kg satellite was built by Matra Espace for the Centre National d'Etudes Spatiales (CNES). It has a box-shaped body measuring 2 x 2 x 4.5 m. Solar arrays extending from a rear-mounted boom span 8.14 m when deployed. Supplied power is 1,000 W. Two High Resolution Visible (HRV) instruments are mounted at the fore end of the central body. The HRVs each have three multispectral bands with 20-m resolution and one panchromatic band with 10-m resolution. The field of view is 2 x 60 km. Injected into polar orbit, SPOT-2, after two months of testing, was declared operational March 23. Earth imagery, used for mapping and forestry, agriculture and geologic studies, is available for commercial use through CNES' SPOT Image. The satellite has a two-year life expectancy.

Uosat 3, 4; Microsats 1-4

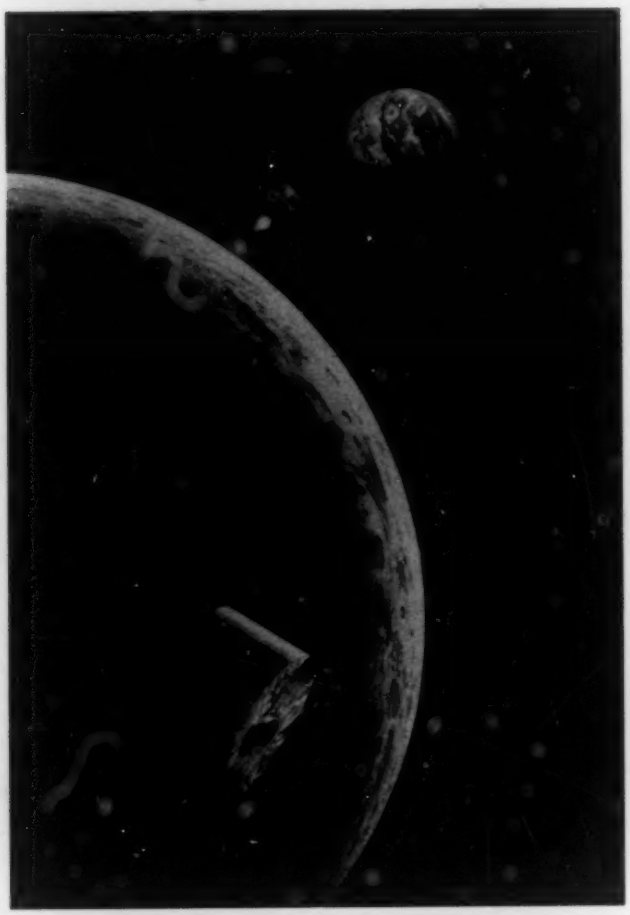
Six small satellites were Ariane-launched January 22 at 01:35. It was the first use of the Ariane Structure for Auxiliary Payloads (ASAP), a ring platform that sits beneath the primary payload around its adapter. The Matra-made fixture can house multiple satellites weighing no more than 200 kg total. The lightweight passengers are deployed by a spring device shortly after third-stage separation. The University of Surrey's Uosat 3 and 4 are rectangular, measuring 0.6 x 0.35 x 0.35 m. With antenna deployed, height is 6 m. Uosat 3 weighed 45.5 kg at launch; Uosat 4, 47.5 kg. Body mounted solar cells provide 30 W of power. Uosat 3 carried a communications package; Uosat 4, technology experiments and CCD camera for earth imaging. Although both were expected to operate five years, Uosat 4 ceased transmitting after 30 hrs. The Microsats, built by Amsat N.A., are part of the amateur radio satellite series. Each weighed 12 kg at launch. Microsats 1 and 4, carrying digital communications equipment and Microsat 2, hosting a voice digital encoder for educational use, are 0.23 x 0.23-m cubes. Microsat 3, carrying imaging equipment, magnetometer and visible light spectrometer is slightly larger at 0.30 x 0.23 m. With booms extended, Microsat height is 0.8 m. Body mounted solar cells supply 6 W. Renamed Pacsat, Dove, Webersat and Lusat after launch, they may also be known by Oscar designators. Each has a three-year design life.

Muses A/Hagoromo

A Japanese scientific satellite carrying a lunar orbiter was launched on a lunar swingby mission aboard an Mu-3S-II from Kagoshima Space Center, 11:46, January 24. Muses A, for Mu-launched Space Engineering Satellite, was placed in a highly elliptical orbit that intersects that of the moon. After launch, the satellite was renamed Hiten for a Buddhist angel who plays music in heaven. It returned engineering data on trajectory, optical navigation and an onboard fault tolerant computer. A joint experiment with the Technical University of Munich, Germany, detects cosmic dust. Hiten's first lunar swingby, March 19, brought it 16,472 km from the moon. As it crossed the moon's orbital path, it released the 12-kg orbiter. A solid motor burn cast Hagoromo, named for the veil worn by the legendary Hiten, into a 22,000 by 9,000-km orbit around the moon. The successful insertion demonstrated Japans' ability to use the swingby technique to achieve lunar orbit. The satellites were developed by the Institute of Space and Astronautical Science. Hiten is drum-shaped, 140 cm in diameter, 79 cm high. It weighed 185 kg at launch. Hagoromo is a 40 by 37 cm polyhedron. Radio contact with Hagoromo was lost after its release. Hiten continues on its elliptical flight, simulating the orbital path of the proposed Geotail spacecraft.

PRC 26/Shiyang Tongbu Tonxin Weixing 4

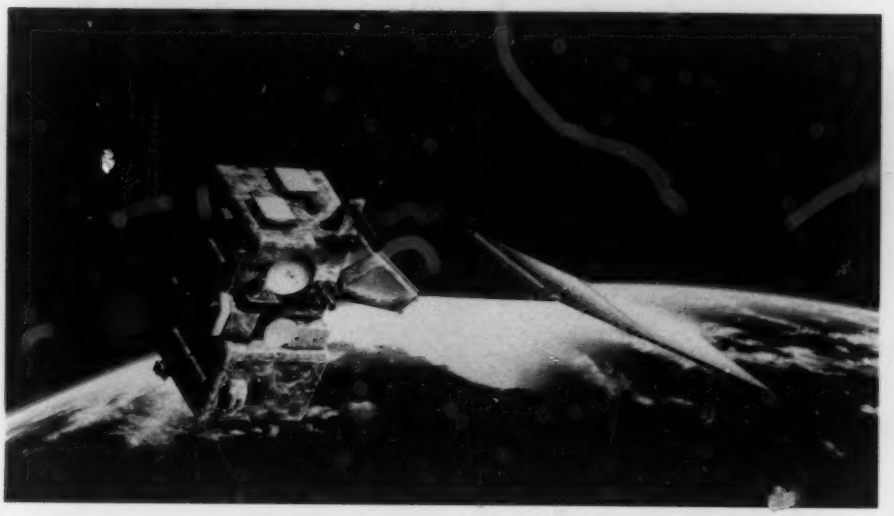
A Chinese communications satellite was launched from Xichang aboard a Long March 3 at 12:27, February 4. Its orbit was circularized February 6 at 01:34 and it arrived on station at 98.5 deg. e within a few days. It is the fifth geosynchronous commsat successfully orbited by the Chinese. PRC 26, a NORAD designation, is also known as Shiyang Tongbu Tonxin Weixing 4, Chinese for Operational Geostationary Communications Satellite. That satellite series is known collectively as Dong Fang Hong 2. PRC 26 is a 2-m cylinder approximately 2.4 m high. The satellite weighed 1,024 kg at launch; 441 kg on orbit.



Muses A

MOS 1B

A Japanese Marine Observation Satellite (MOS 1B), was one of a triple payload launched from Tanegashima Space Center aboard a two-stage H-1 at 01:33, February 7. Redesignated Momo 1B (Peach Blossom) once in orbit, the satellite is the second of two remote sensing craft observing oceanic phenomena and earth's terrain. Developed by the National Space Development Agency of Japan (NASDA), MOS 1B carries three radiometers to observe and measure sea sediment and surface features, vegetation, snow pack, cloud distribution, temperature and atmospheric water vapor. Two instruments observe in visible and infrared; a third scans in two radio frequency bands. A Data Collection System Transponder relays information from buoys and ground sites to centralized stations. MOS 1B is box-shaped, measuring 1.3 by 1.5 by 2.4 m. A three-panel solar array provides 640 W at beginning of life and adds 5.28 m to the overall satellite length when deployed. MOS 1B weighed 740 kg at launch. The satellite was originally the prototype for MOS 1, launched in 1987. It was refurbished and upgraded for the mission and has a two-year life expectancy.



Mos 1B *Courtesy NASDA*

Debut, JAS 1B

A Japanese technology experiment and amateur radio satellite were launched with MOS 1B aboard an H-1 from Tanegashima Space Center, February 7 at 01:33. The Deployable Boom and Umbrella Test (Debut) carried a retractable 1.46-m boom and 24-panel aerodynamic umbrella to verify deployment operations in space. Such umbrellas may one day be

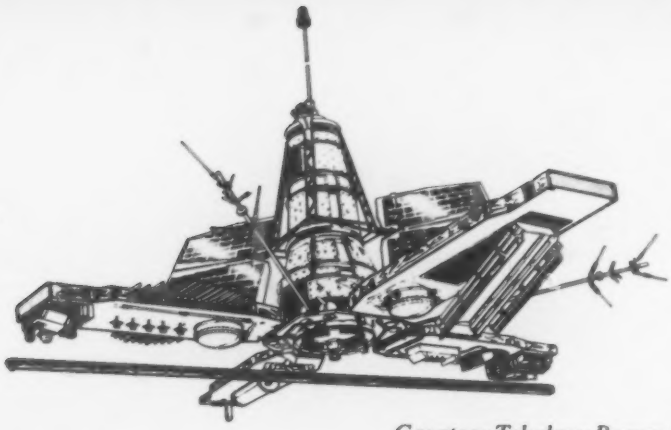
used to lower the orbits of geostationary satellites or as aerodynamic braking mechanisms for lunar/planetary missions. Developed by the National Aerospace Laboratory, Debut is a 26-sided polyhedron measuring 0.4 m in diameter and 0.47 m long with boom and umbrella stowed. On orbit the structure expands to 1.95 m with boom deployed and 0.95 m in diameter with umbrella opened. Debut was separated from the second stage 60 mn, 21 sec after liftoff. The Japanese Amateur Radio Satellite (JAS 1B) followed 5 seconds later. JAS 1B succeeds JAS 1 (Oscar 12), Japan's first communications satellite linking amateur radio operators. JAS 1B operates as a store and forward message service. Uplink frequency is 144 MHz; downlink is at 435 MHz. The satellite, developed by the Japan Amateur Radio League, is 0.44 m in diameter, 0.47 m long. A turnstile antenna ring at its base receives signals, four transmitting antennas extend from the top. Body mounted solar cells supply 10 W. JAS 1B and Debut each weighed 50 kg at launch.

LACE/RME

A dual payload carrying laser defense experiments was launched aboard a Delta 2 from Cape Canaveral, 19:15, February 14. The Low-power Atmospheric Compensation Experiment (LACE) carried visible, infrared and phased sensors to measure distortions in laser beams targeting it from earth. The satellite, built by the Naval Research Laboratory, also carries an ultraviolet plume instrument to determine the best wavelengths to track rocket plumes, and an Army Background Experiment to measure neutron activity in space. The Relay Mirror Experiment (RME) satellite hosts a 24-inch mirror to test laser pointing technology by deflecting ground-based beams back to earth. Results from experiments aboard both satellites will aid in the design of laser defenses against missile threats. LACE weighed 1,430 kg at launch. RME, built by Ball Space Systems Division, weighed 1,040 kg.

RME *Courtesy Ball Space Systems*

Okean 2



Courtesy Teledyne Brown Engineering

Okean 2

The second named satellite in this Soviet oceanographic series was launched by a Tsyklon (F-2) booster from Plesetsk on February 28 at 00:56. The satellite carries sets of scanning, optical/mechanical and radiophysics equipment for continuous observations of the world's oceans. Okean 2 is a 0.9 m cylinder about 3.5 m long. Two solar panels extend from its midsection. Four instrument vanes extend perpendicular from its base. Okean 2 weighs about 1,900 kg. Okean 1 was launched in July 1988. Previous satellites in the series include Kosmos 1500, 1602, 1766 and 1869.

STS-36

The first of two scheduled 1990 DoD shuttle flights was launched from Kennedy Space Center, February 28 at 07:50. Atlantis carried a military payload and a five-person crew. The flight was commanded by John O. Creighton and piloted by John H. Casper. David C. Hilmers, Richard M. Mullane and Pierre J. Thuot were mission specialists. Atlantis' classified mission placed it in a 62-deg. inclination orbit, the highest yet flown by the shuttle. The orbiter remained in space for 4 days, 10 hrs, 18 mns, touching down on Edwards AFB runway 23 at 18:08, March 4.

INTELSAT 6 F3, F4

An International Telecommunications Satellite Organization (INTELSAT) new generation satellite was launched at 11:52, March 14, by a Titan III. A booster separation failure cast INTELSAT 6 F3, the second in the series, into a non-operational substationary orbit. The satellite carries 38 C-band and 10 K-band transponders, providing telephone, TV and data service to

INTELSAT 6 *Courtesy Hughes Space & Communications*

large ground stations and small terminals. INTELSAT 6 can accommodate 120,000 phone calls and three TV channels simultaneously. Built by Hughes Space and Communications Group for INTELSAT, the new series satellites are the largest commsats flown to date. INTELSAT 6 is drum-shaped, 3.6 m in diameter and 11.7 m tall, weighing 4,215 kg at launch; 2,560 kg on orbit. Body mounted solar arrays provide 2,250 W at end of life. The satellites have a planned 14-year service life. F4 was launched aboard a Titan III June 23 at 11:19. Located above 27.5 deg. w, F4 will absorb th transmission demand over the north and south Atlantic area. F3, propelled into a safe orbit, awaits rescue via a proposed 1992 shuttle mission.

Ofeq 2

Israel's second satellite, Ofeq 2, was launched via a Shavit booster at 12:02, April 3, from Yavne launch facility in the Negev desert. The experimental scientific satellite tested two-way communications, remote control, and onboard system performance in a space environment. Built by Israel Aircraft Industries for the Israeli Space Agency, Ofeq 2 was an octagonal prism, measuring 2.3 m tall, 1.2 m wide at the bottom, 0.7 m wide at the top. It weighed 160 kg. Body mounted solar cells supplied 246 W of power. Telemetry was transmitted via an S-band communications system. Ofeq 2 reentered earth's atmosphere July 9.

Pegasus/Pegsat

The first air-launched booster delivered two payloads into orbit after its release from a B-52 at 18:10, April 5. The Pegasus rocket, a joint development of Orbital Sciences Corp. and Hercules Aerospace Co., is designed to lift small, lightweight payloads into low-earth orbit. Its maiden flight commenced at 18:03, when it took off from Edwards AFB tucked beneath the wing of a B-52. The aircraft, acting as a first stage, carried the 15-m-long, delta-winged vehicle to an altitude of 43,000 ft. Pegasus was released above the Pacific, free falling for five seconds before its first-stage solid rocket motor ignited. An 82-second burn sped Pegasus skyward at 5,800 mph. The second stage fired nine seconds after first stage burnout, sending Pegasus to an altitude of some 650,000 ft. After a six-minute coast, the third stage separated and its motor fired to increase the craft's speed for orbital insertion. The dual payload was inserted into the targeted 500-km polar orbit at 19:19. Pegsat, a NASA experiment, remained attached to the third stage. A Navy satellite was ejected into a separate orbit. The NASA payload consisted of gas-bearing canisters originally slated for the CRRES mission. They released a cloud of barium April 15, giving scientists a means to study particle interaction with earth's magnetic field.

Asiasat 1

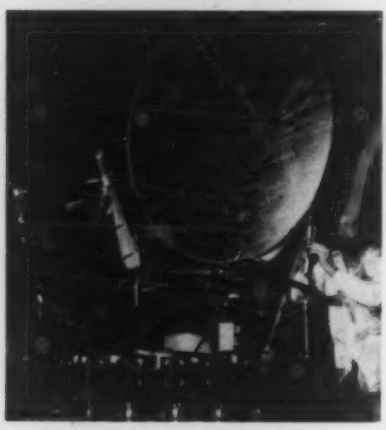
The former Westar 6, cast into an unusable orbit by an upper stage failure in February 1984, and retrieved by the shuttle that November, lifted off for the second time, 13:30, April 7, on a Chinese Long March 3. The launch from the Xichang launch facility was the first time an American-made spacecraft had been orbited by the Chinese. After its retrieval and return to earth, Westar 6 was sold to an international consortium; Hughes Space and Communications Group, the satellite's manufacturer, refurbished the craft for the Asia Satellite Telecommunications Co., Ltd. Asiasat 1, stationed above 105 deg. e, is the first of a series of privately operated commsats providing telephone, telex, facsimile, data and TV broadcast services to an area housing half the world's population. Two beams cover an area from Korea to the Middle East, and Mongolia to Malaysia. Each of the payload's 24 C-band transponders can accommodate 2,400 one-way voice circuits or one color TV channel. Asiasat 1 is a standard Hughes HS 376 bus, 2.1 m in diameter, 6.6 m high with solar drum extended and antenna reflector deployed. Beginning of life power is 1,060 W. It weighed 1,442 kg at launch.

Foton 3

A dedicated materials processing satellite carrying a French microgravity research payload was launched via a Soyuz booster from Plesetsk Cosmodrome at 17:00, April 11. The Centre National d'Etudes Spatiales (CNES) experiment, called Crocodile, contained materials to produce high-quality organic crystals for new generation electronics. It is the second French payload to fly on a Soviet Foton. The Foton houses a 2.3-m spherical descent module for return to earth. A double-cone retrorocket extends from the base of the sphere, a small cylindrical unit atop the module houses chemical batteries to power the experiments. Overall satellite length is 5 m; mass is 6,200 kg. Foton, with Crocodile aboard, returned to earth April 27 at 06:15.

Palapa B-2R

Five and a half years after the shuttle rescued it from an unusable orbit, Palapa B-2R was relaunched by a Delta rocket from Cape Canaveral at 22:28, April 13. The Indonesian communication satellite's original flight was cut short in February 1984, when an upper stage malfunction left it in low-earth orbit, far from its geosynchronous destination. Nine months later, Palapa B-2 and another stranded craft, Westar 6, were retrieved by STS-51A and returned to earth. The refurbished satellite, built for Permutel by Hughes Space and Communications Group, provides voice, video and data service to the 13,677 Indonesian islands. Palapa B-2R's 24 C-band transponders can handle 12,000 simultaneous telephone calls or 24 TV broadcasts. One of the Hughes HS 376 series, Palapa is a 2.1-m drum, 2.8 m high. With solar drum and antenna reflector deployed, height is 6.6 m. Solar panels provide 1,062 W at beginning of life, expected to be 10 years. The satellite weighs 650 kg on orbit. Stationed above 107.7 deg. e, it joins Palapa B1, shuttle-launched in 1983 and Palapa B-2P, flown in 1987.



Palapa B-2R

Courtesy Hughes Space & Communications

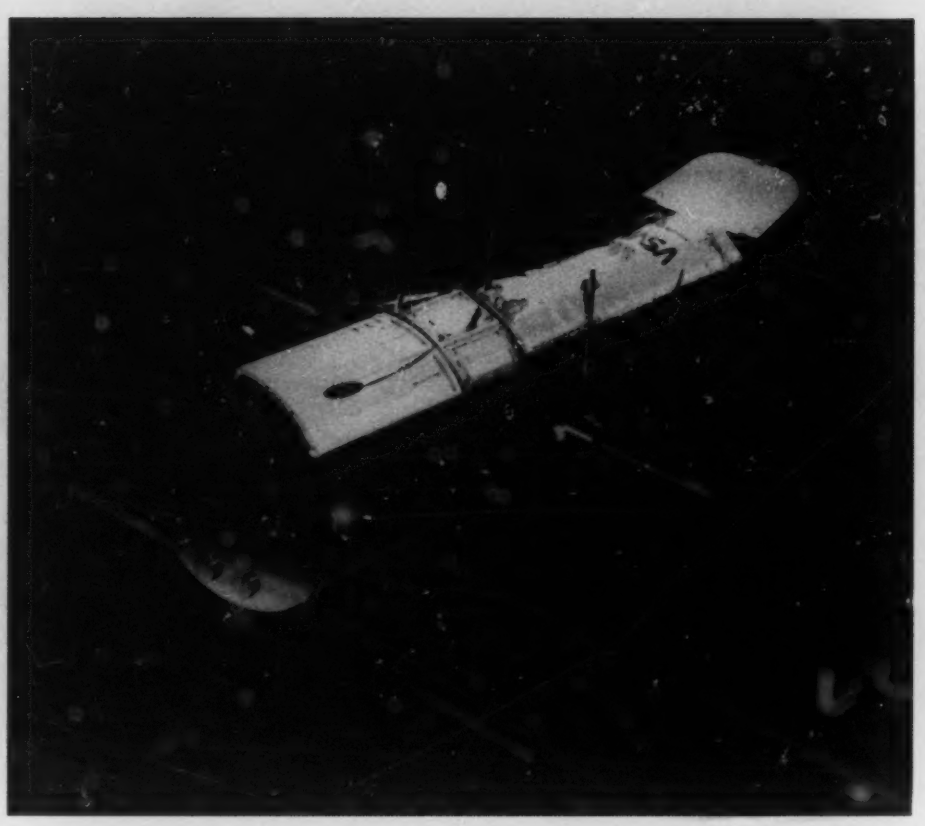
STS-31

The space shuttle Discovery lifted off with a five-person crew, the Hubble Space Telescope (HST) and five onboard experiments, April 24 at 12:34. Total orbiter weight at launch was 117,430 kg, 11,862 kg of which was payload. The mission was commanded by Loren J. Schriver and piloted by Charles F. Bolden. Steven A. Hawley, Bruce McCandless and Kathryn D. Sullivan were STS-31 mission specialists. The major objective of Discovery's 10th flight was the HST deployment. Astronaut Hawley released the telescope from the RMS on orbit 20, 31 hours after launch. The rest of the mission was devoted to photography and onboard experiments. To cast HST into an orbit that guaranteed longevity, Discovery soared to 600 km — the highest shuttle altitude to date. The record height permitted the crew to photograph earth's large-scale geographic features not apparent from lower orbits. Motion pictures were recorded by two IMAX cameras. Experiment activity included a biomedical technology study, advanced materials research; particle contamination and ionizing radiation measurements; and a student science project studying zero gravity effects on electronic arcs. Discovery's reentry from its higher than usual orbit called for a 4-mn, 58-sec deorbit burn, the longest in shuttle history. Discovery touched down on Edwards AFB runway 22 at 13:49, April 29, after 5 days, 1 hr, 16 mn.

Hubble Space Telescope

The first of NASA's four scheduled Great Observatories was placed in orbit by the shuttle's remote manipulator arm at 19:39, April 25. The Hubble Space Telescope's (HST) mission to study the far reaches of the universe from an orbital position above atmospheric distortions did not get off to a good start. Its release from shuttle was delayed some six hours by a stubborn solar panel. Soon after deployment HST was plagued by antenna problems, a stuck aperture door and a penchant to go into "safe mode." In addition, the solar panels flex when entering or exiting eclipse; and system checkout revealed a hairsbreadth flaw in the instrument's 2.4-m primary mirror.

The 10,863-kg observatory is 13.3 m long, 4.3 m in diameter. Two 2.8-cm by 12-m solar panels containing 48,000 solar cells supply 5,000 W of power. HST houses five scientific experiments and an optics assembly. The optics consist of the primary mirror and an 0.3-m secondary mirror. Light collected and intensified by the mirrors is directed to a focal plane where the instruments reside. The Wide Field/Planetary Camera views distant galaxies and seeks new planetary systems. The Faint Object Camera photographs faint stars at the farthest possible distances. A High Speed Photometer measures brightness. The Faint Object and Goddard High Resolution Spectrographs determine an object's chemical composition, temperature,



Hubble Space Telescope

pressure and density. The Goddard Spectrograph observes in the infrared, all other Hubble instruments look in visible light.

The flaw — a spherical aberration attributed to a spacing error in a testing device — prevents images from being as sharply focused as desired. Although it was first believed some 50 percent of the mission would be lost, computer enhancement has salvaged much of the imagery. HST has returned unprecedented data from distant galaxies and imaged details of a young star cluster 160,000 light years from earth. It sent back detailed shots of the supernova that exploded in 1987, and Saturn's great white spot.

Hubble was designed for a 15-year service life based on periodic on-orbit maintenance. The first scheduled mission in 1992 or 93 will focus on the solar panel flexure and the mirror flaw.

NASA plans to complete the picture of the electromagnetic sky with gamma ray data from the Gamma Ray Observatory, due for launch in 1991, X-ray studies by the Advanced X-ray Astrophysics Facility and infrared viewing via the Space Infrared Telescope Facility, planned for later in the decade.

Resurs-F 6-9

The Soviet Union launched four Resurs-F remote sensing satellites aboard A-2 vehicles from Plesetsk in 1990. The satellites are used for civil earth observations and can carry commercial microgravity payloads. A reentry module returns film and payloads to earth, usually two weeks after launch. There are two Resurs-F classes. One carries two long-focus cameras, three multispectral cameras and a stellar camera, called Priroda-4 by the Soviets. The other houses a multispectral and stellar camera. The stellar cameras allow sky pictures to be taken simultaneously with ground shots to check satellite orientation. The first Resurs-F, launched 07:19, May 29, and the fourth, launched 11:00, September 7, carried microgravity experiments for a German consortium, Intospace GmBH. COSIMA (Crystallization of Organic Substances in Microgravity Application) flew on F6 and was recovered on June 14. CASIMIR (Catalyst Studies for Industry through Microgravity Research) flew on F9 and was recovered September 21. Those missions carried the Priroda 4 camera system, as did F8, launched August 16, 19:55. A two-camera Resurs-F flew on July 17, 09:30. The satellite is about 6.5 m long, including a conical 1.9-m propulsion system and a 2.1-m double-cone instrument module housing the retrorocket. Diameter of the spherical reentry vehicle is 2.3 m. Satellite mass is 6,300 kg.

Rosat

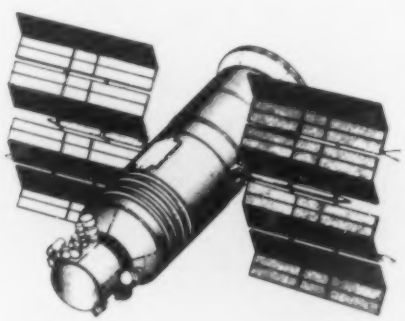
The West German Roentgen Satellite (Rosat), hosting a large telescope/camera system to survey the X-ray sky, was Delta-launched from Cape Canaveral, June 1 at 21:48. Following two months of system checkout, the astronomy satellite began an 18-month mission to scan the heavens for new X-ray sources and perform detailed studies of specific objects. The 2,426-kg satellite, built by Dornier for the German Federal Ministry of Research and Technology, measures 4.7 by 2.2 by 4.3 m. Three solar panels forming a 4.5-m octagon are affixed lengthwise to the large telescope. The arrays supply 1,040 W. Primary payload is the large German-made X-ray telescope. It has a 2.4-m focal length and 1.8-arc-second resolution. A smaller .53-m focal length wide-field camera, viewing in extreme ultraviolet wavelengths, was supplied by a United Kingdom consortium. During the first six-month segment of the mission, Rosat X-ray images revealed an apparent structure to the universe, possibly caused by quasar clusters. It also revealed some 1,000 new sources of extreme ultraviolet radiation.

Insat 1D

The last in a series of multipurpose satellites providing communications and weather forecasting service for India was Delta-launched, 05:52, June 12 from Cape Canaveral. Insat 1D, built by Ford Aerospace (now Loral Inc.) for the Indian Space Research Organization houses 12 C-band transponders for telephone and data communications and two S-band transponders for direct broadcast service. A radiometer returns meteorological imagery for long-term weather forecasting, storm warning and resource management. Insat 1D, positioned above 83.1 deg. e, replaces Insat 1B, launched in 1983 and near the end of its life expectancy. The 1D launch was delayed almost a year when a launch pad hoist cable broke and damaged Insat's C-band reflector; this mishap followed solar panel damage suffered during the 1989 San Francisco earthquake. The fourth in the Insat 1 series, the satellite is box-shaped, measuring 1.55 x 1.42 x 2.18 m. A solar sail and 11.5 sq. m solar panel extend overall length to 19.4 m when deployed. Solar panels provide 1,200 W at beginning of life. Insat 1D weighed 1,190 kg at launch; 700 kg on orbit. It has a seven-year life expectancy.

Gamma

A Soviet gamma ray observatory carrying equipment supplied by France and Poland lifted off from Tyuratam aboard a Soyuz (A-2) booster at 11:00, July 11. The 7,350-kg science satellite, built around a Soyuz/Progress class instrument module, measures 8 m long and 2.3 m in diameter. Solar arrays span 12 m. Gamma carries a large gamma ray telescope and two smaller telescopes called Disk and Pulsar Kh-2. Two vidicon cameras connected with the main telescope were provided by France. The Polish Academy of Science and Warsaw Technical University contributed a camera-based attitude control system.



Gamma *Courtesy Teledyne Brown Engineering*

Badr-1

Pakistan's first entry into the orbital arena was launched aboard the maiden flight of the Chinese Long March 2E, at 00:40, July 16. The launch from Xichang lifted the 52-kg Badr-1 into a low-earth orbit from where a digital communications experiment was demonstrated. It was expected to operate for 15 to 20 minutes during three orbits a day. Built by Suparco, the Pakistan national space agency, the satellite is a 26-sided polyhedron, 483 mm in diameter. Signals ended after 35 days; it decayed on December 8. Badr-1 flew as a piggyback payload along with a mass model of Aussat, an Australian commsat. Two Aussats are scheduled for Long March 2E launch in 1991 and 1992. The 7,353-kg model remained attached to the Long March second stage, decaying October 9. The new Long March 2E uses a stretched core booster based upon the Long March 2C and 3. Four liquid-fueled strap-on boosters with one engine each, double the power of the core stage which houses four similar engines. The booster can inject up to 8.8 metric tons into low-earth orbit, or 4,500 kg into geosynchronous transfer orbit.

TDF 2

An Ariane 44L tandem-launch boosted the French TDF-2 communications satellite into orbit at 22:25, July 24. TDF-2 is the second five-channel direct broadcast satellite built for Telediffusion de France by the European Eurosatellite consortium. It provides TV and radio programming to France, surrounding European countries and a sliver of North Africa using the D2 MAC Packet standard. TDF-2 operates at 11/12 GHz, with a maximum EIRP of 64 dbW per channel. Box-shaped, the satellite measures 6.2 by 2.4 by 2.2 m, and spans 19.3 m with solar arrays deployed. Arrays provide 3,300 W at end of life. TDF-2 weighed 2,096 kg at launch, 1,255 kg on orbit. It joins TDF-1, Ariane-launched in 1988, at 19 deg. w long. The satellite has a nine-year life expectancy, but suffered two transponder failures two months after achieving operational status. TDF-1 also lost two transponders. The losses have not affected service, but do limit backup options. The French government announced in November that the TDF program would be discontinued in favor of more current technology.

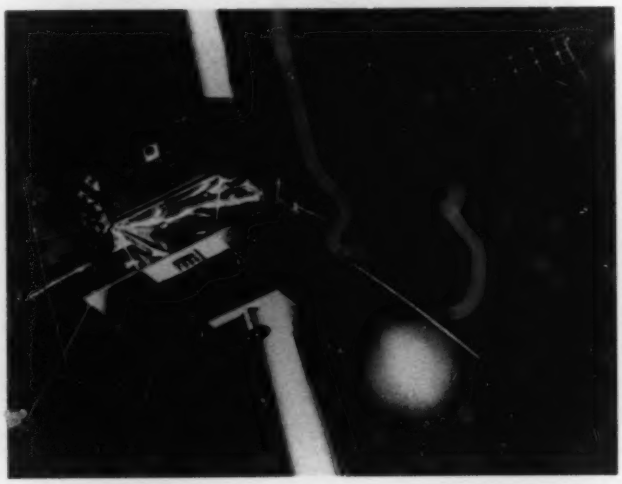
DFS Kopernikus 2

The German telecommunications satellite, DFS Kopernikus 2, was lofted with TDF-2 aboard an Ariane 44L, 22:25, July 24, from Kourou, French Guiana. The satellite is the second in a two-satellite system providing telephone service, television and radio broadcasts to Germany and neighboring

East and West European countries. It carries 11 transponders, three operating at 14/11 GHz, seven at 14/12 GHz and one at 30/20 GHz. Maximum EIRP is 54 dbW. DFS Kopernikus 2 was built by a German consortium, R-DFS, for Deutsche Bundespost Telekom. It is a 3.4 by 1.7 by 2.9 m box, spanning 15.4 m with solar arrays deployed. End-of-life power is 1,550 W. It weighed 1,418 kg at launch; 850 kg on orbit. DFS Kopernikus 2, stationed above 28.5 deg. e long., supplements the coverage area of the Flight 1 satellite on orbit since June 1989. It has a 10-year design life.

CRRES

The Combined Release and Radiation Effects Satellite (CRRES) was launched from Cape Canaveral aboard an Atlas-Centaur at 17:21, July 25. The satellite, sponsored by NASA and the Department of Defense, embarked on a one-to-three-year study of the earth's magnetic field. CRRES carried 24 canisters containing barium, lithium, strontium and calcium. When released in vapor form, the sun's ultraviolet rays ionize the chemicals, transforming them into colorful clouds that spread along earth's magnetic field. By "painting" the heavens, scientists can study the interaction of plasmas with magnetic fields, the meeting of the upper atmosphere with the ionosphere, and the structure of low-altitude electric fields. CRRES' orbit takes it through the inner and outer Van Allen belts, enabling studies of the radiation environment on advanced microelectronic components. Built by Ball Space Systems, CRRES weighed 1,629 kg at launch. The satellite measures 2.63 m across and 2.28 m high. Two 1 by 2.56-m solar panels affixed parallel to the upper body supply an average 383 W after one year. The first chemical releases occurred September 10 and 12, near 17.5 deg. s lat., 161 deg. w long., and 18 deg. s lat., 180 deg. w long., respectively. Releases will continue through 1991.



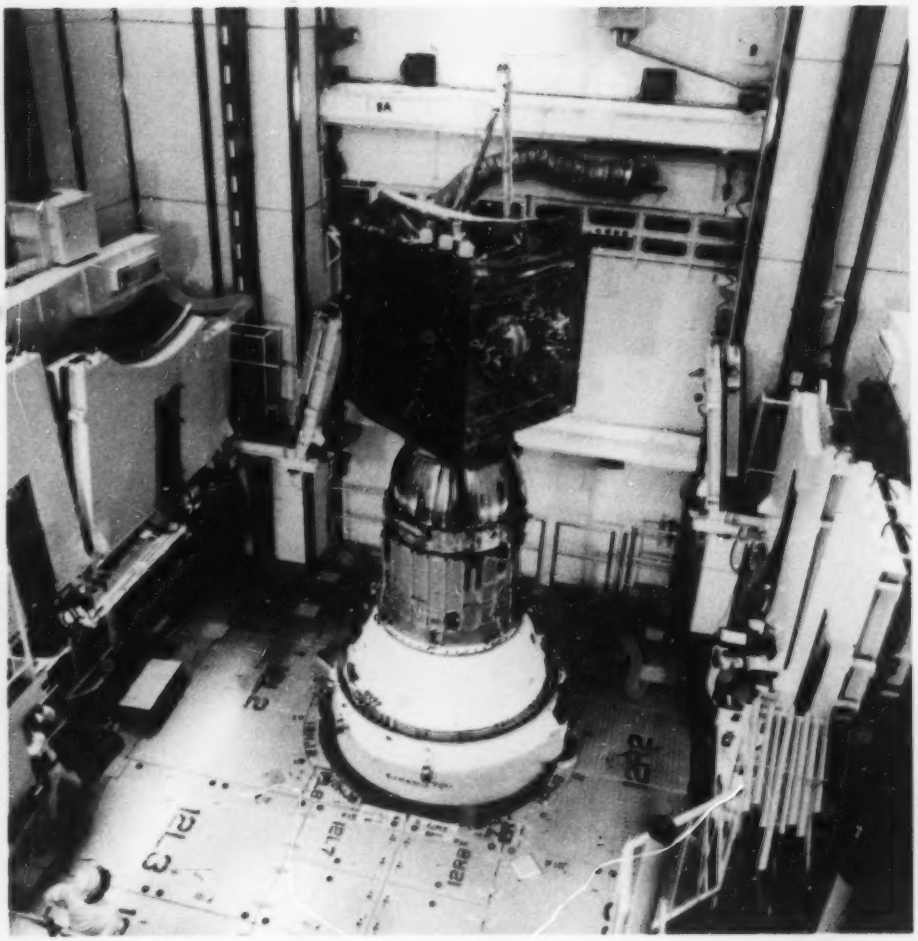
CRRES *Courtesy Ball Space Systems*

BSB Marcopolo 2

The second of two British Satellite Broadcasting (BSB) commsats was Delta-launched from Cape Canaveral at 00:42, August 18. Marcopolo 2 joins a sister craft at 31 deg. w, to provide high-power direct broadcast signals to United Kingdom users with antennas as small as 0.3 m. The high power necessary for reception on small antennas — 110 W for each of three TV channels — was achieved by linking two 55-W traveling wave tubes in parallel to a common power supply. Each Marcopolo houses five Ku-band transponder channels, but only three can be at full power at one time. With both satellites on station, five channels can be beamed at full power. The twins will be maneuvered to stay in close proximity allowing signals from both to be beamed at the same spot. Built for British Satellite Broadcasting by Hughes Space and Communications Group, Marcopolo 2 is a 2.1-m diameter drum, 2.7 m tall. With solar drum deployed and antenna reflector raised, overall height is 7.2 m. Body mounted solar arrays provide 1,000 W at the beginning of its 10-year life. The satellite weighed 1,220 kg at launch; 679 kg on orbit.

BS-3A

A new generation Japanese Broadcasting satellite, lifted off from Tanegashima Space Center aboard an H-I, August 28 at 09:05. A follow-on to the BS-2 series providing direct broadcast service to all of Japan and the islands of Okinawa and Ogasawara, BS-3A features more transponder output — from 100 to 120 W, an added channel — from 2 to 3, and longer life — from 5 to 7 years. An experimental 20-W wideband transponder will test high-definition TV transmission. The payload operates at 14/12 GHz. Built by GE Astro Space and Nippon Electric Company, BS-3A is based on GE's Satcom 3000 bus and incorporates Japanese transponders, antenna and apogee kick motor. The box-shaped satellite measures 1.3 by 1.6 by 1.6 m, spanning 15 m with solar panels deployed. The shaped beam parabolic antenna extends overall height to 3.2 m on orbit. The arrays provide 1,443 W at beginning of life. BS-3A weighed 1,115 kg at launch; 550 kg on orbit. As is customary with Japanese launches, the satellite was renamed in flight. Yuri (lily) 3A reached its assigned geosynchronous station at 110 deg. e in October. Operations were turned over to the Telecommunications Satellite Co. of Japan.



BS-3A *Courtesy NASDA*

Eutelsat 2 F1

A new generation European telecommunications satellite was tandem-launched with Skynet 4C by an Ariane 44LP at 10:46, August 30. Eutelsat 2 F1 is the first of six commsats built for the European Telecommunications Satellite Organization (Eutelsat) by an Aerospatiale-led consortium. The satellites, follow-ons to the ECS (European Communications Satellite) series, offer telephone, telex, data transmission and TV services to commercial users over 16 50-W Ku-band transponders. Beam flexibility allows users to target signals to specific geographical areas. Signals can be received on antennas as small as 60 to 70 cm in diameter. Eutelsat 2 is box-shaped, measuring 2.7 by 1.3 by 1.3 m. Solar arrays spanning 22.4 m supply 3,000 W over the satellite's seven-year design life. It weighed 1,878 kg at launch, 935 kg on orbit. Eutelsat 2 is stationed above 13 deg. e and replaces an aging ECS 1.

Fengyun-1 F2

China's second sun-synchronous meteorological satellite was launched aboard a Long March 4 from Taiyuan, September 3 at 00:53. The satellite carries two 1.1-km resolution scanner radiometers. Five spectral bands — four visible light and one infrared — allow Fengyun-1 to obtain images during day and night passes. It is gathering domestic and foreign weather data for weather forecasting. Data is formatted for transmission to world-wide users. Fengyun-1 F2 measures 1.2 m high x 1.4 m wide by 1.4 m long; solar arrays span 8.6 m. It weighs 881 kg. China's first meteorological satellite, launched in 1988, lost its attitude control system six weeks after launch. Flight 2 carries an improved control system. Fengyun-1 F2 was accompanied at launch by two atmospheric research balloons, Qi Qui Weixing 1 and 2. The spheres were inflated on orbit to 3 and 2.5 m.

Fanhui Shi Weixing-1, F12 (PRC 33)

A Chinese recoverable satellite was launched at 06:13, October 5 from the Jiaquan launch facility aboard a Long March 2C booster. It was the 13th flight in the series, the 12th to succeed. Fanhui Shi Weixing, for Recoverable Test Satellite, is dome-shaped, 3.14 m long with a 2.2 m base. The descent craft is beehive-shaped, 1.5 m long with a 1.6 m base. Overall mass is 2.6 metric tons; descent capsule mass is 2,080 kg. The capsule, carrying plants and animals for zero-gravity studies, was recovered after 8 days in orbit on October 13 at 03:59. The bus decayed October 23.

STS-41

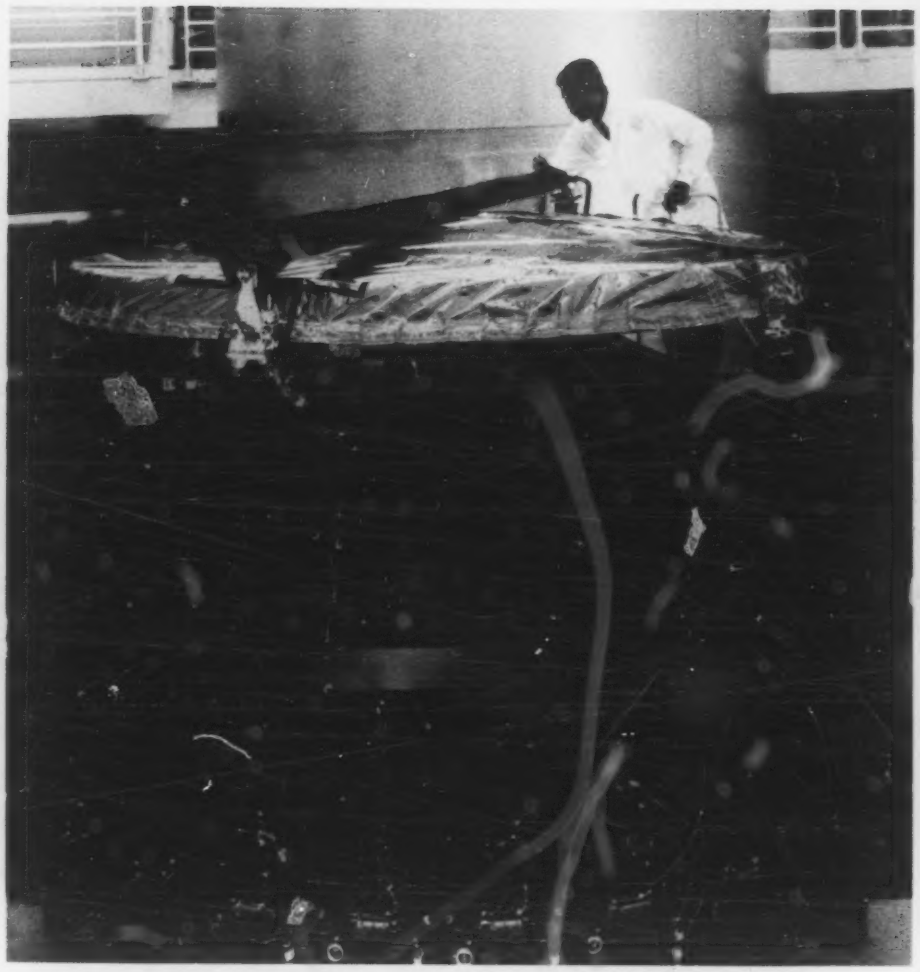
Laden with ESA's Ulysses spacecraft, eight experiments and a five-person crew, the shuttle Discovery lifted off from Kennedy Space Center pad 39B at 11:47, October 6. Orbiter/cargo weight at ignition was 116,117 kg; total vehicle weight was 204,981 kg. The flight crew consisted of Richard N. Richards, commander; Robert D. Cabana, pilot; Bruce E. Melnick, William M. Shepherd and Thomas D. Akers, mission specialists. The Ulysses solar explorer was deployed six hours after launch at the onset of orbit five. With Ulysses safely enroute to Jupiter and a gravity-boost to the sun, the crew focused on the onboard experiments. Sixteen rats were monitored for zero-gravity effects on physiological responses to drugs. A small controlled fire was lit to study the spread of flames in space. The robotic arm, hosting solar panel materials flown on INTELSAT 6 and some 48 samples planned for the space station, was deployed on mission day two. The materials were

exposed to a flow of atomic oxygen for two days. The experiment will reveal what degradation the crippled INTELSAT 6 will experience before its 1992 shuttle rescue, and allow space station designers to evaluate its maintenance needs. Discovery returned to earth at 13:57, October 10, landing on Edwards AFB runway 22 after 65 orbits totaling 4 days, 2 hrs and 10 minutes of flight.

Ulysses

A European solar sojourner bound for a flyby science mission at the sun's poles was deployed from the shuttle Atlantis at 18:48, October 6. Ulysses' unique trajectory will take it below the ecliptic plane to pass the solar south pole and then above the ecliptic to pass the north pole. To achieve the energy needed to fly out of the ecliptic, Ulysses will first journey to Jupiter, using that planet's massive gravity to slingshot it downward and back to the sun. The maneuver requires pinpoint targeting; Ulysses must, after an 800-million-km flight, arrive within a 160-km corridor at Jupiter. To ensure accuracy, Atlantis performed a series of maneuvers before Ulysses deployment to verify position data of the IUS inertial platform. About 65 minutes after release from the shuttle cargo bay, two IUS burns boosted Ulysses' orbital speed to 25,580 mph. A PAM upper stage propelled the craft to 234,130 mph relative to earth — the fastest escape velocity ever achieved by a space vehicle. Ulysses carries nine instruments to collect data on sunspots, solar flares, and the temperature, radiation and chemical environment at solar polar regions. Built by Dornier for the European Space Agency, Ulysses is 3.2 m long, 3.3 m wide and 2.1 m high. A 1.65-m parabolic antenna is mounted atop the main body. A monopole antenna extends 7.5 m from the bottom; a magnetometer boom extends 5.6 m from one end; a radioisotope thermoelectric generator, providing 285 W at mission start, extends from the other end. A radial dipole antenna spans 72.5 m. Ulysses weighed 367 kg at launch. Enroute to its February 1992 encounter with Jupiter, the craft is gathering data on the interplanetary medium and solar wind. It will conduct a five-month study of the solar south pole in 1994 from a distance of about 2 AU. One year later it will undertake similar studies in the north polar region. Ulysses will be the first spacecraft to chart the sun in three dimensions.

Ulysses *Courtesy JPL*



SBS 6 *Courtesy Hughes Space & Communications*

SBS 6

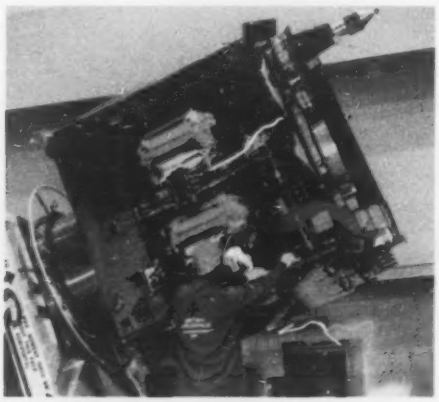
A telecommunications satellite providing video broadcast and direct-to-home TV service was dual-launched aboard an Ariane 44L, from Kourou at 22:58, October 12. Built for Hughes Communications Inc. (HCI) by Hughes Space and Communications Group, SBS 6 carries 19 41-W Ku-band transponders and 11 spares. The powerful channels allow small, portable ground antennas to receive transmissions. Stationed above 99 deg. w, SBS 6 covers the continental U.S. The satellite is slated to backup other older craft in the HCI network. In the short term, however, new customers may lease transmission capacity. A Hughes HS 393 series bus, SBS 6 is drum-shaped, measuring 3.6 m in diameter, 3.6 m high. Deployed height on orbit is 9.4 m. The satellite weighed 2,478 kg at launch; 1,514 kg on orbit. Declared operational November 7, it has a 15-year life expectancy.

Galaxy 6

Joining SBS 6 aboard an Ariane 44L, Galaxy 6 lifted off from Kourou, French Guiana, October 12 at 22:58. The telecommunications satellite, owned and operated by Hughes Communications Inc. (HCI), will increase system capacity and serve as an on-orbit spare for five other Galaxy/Westar satellites. It provides video and broadcast transmissions to occasional users, including local cable and TV stations. Built by Hughes Space and Communications Group, Galaxy 6 carries 24 C-band transponders, each able to accommodate one analog video signal or a combination of compressed video, voice and data signals. The satellite is one of the Hughes HS 376 series, a 2.1-m drum standing 6.6 m high with solar panels and antenna reflector deployed. It weighed 1,212 kg at launch, 708 kg on orbit. Galaxy 6 is positioned above 91 deg. w, covering the continental U.S. It began commercial operations on October 29 and has an expected 13-year service life.

Inmarsat 2 F1

The 200th Delta launch injected a new-generation mobile communications satellite into orbit from Cape Canaveral at 11:16, October 30. Inmarsat 2, built by a British Aerospace-led consortium for the International Maritime Satellite Organization (Inmarsat), is box-shaped, 2.5 m high by 1.5 m long by 1.4 m wide. Solar arrays spanning 15.2 m provide 1,200 W. It weighed 1,385 kg at launch; 690 kg on orbit. The communications payload, supplied by Hughes Aircraft Company, provides 250 ship-to-shore, shore-to-ship, aeronautical and land mobile voice circuits. The mobile link is via L-band; fixed ground links via C-band. The payload uses four separate cup-dipole phased-array antennas for both frequencies. Stationed above 64.5 deg. e, Inmarsat 2 increases transmission capacity over the Indian Ocean area by a factor of six. The satellite's L-band service is dedicated to aeronautical use, strengthening Inmarsat's coverage in that market. Three more Inmarsats are scheduled for launch over the next year.



Inmarsat 2

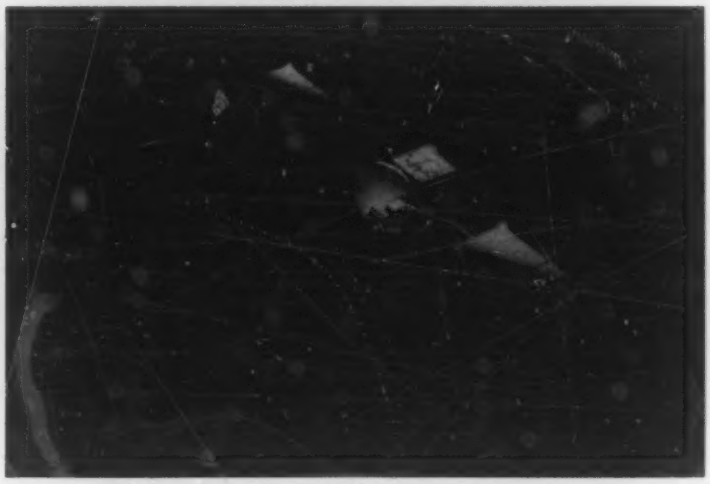
Courtesy British Aerospace

STS-38

Flying a military mission, the shuttle Atlantis lifted off from Kennedy Space Center pad 39A, November 15, at 23:48. STS-38's crew included Richard O. Covey, commander; Frank L. Culbertson, pilot; Charles D. Gamar, Robert C. Springer, and Carl J. Meade, mission specialists. Scheduled to land at Edwards AFB after a four-day flight, Atlantis was rerouted to Kennedy Space Center due to high winds and rain at the California site. The landing was delayed one day in the hopes that conditions at Edwards would improve. The shuttle touched down at 21:42, November 20, after 80 orbits and 4 days, 21 hrs, 54 mns in space.

Satcom C-1

One of two communications satellites dual-launched on an Ariane 42P, Satcom C-1 lifted off November 20 at 23:11. The satellite, built for GE American Communications by GE Astro Space, provides C-band video, voice and data service to commercial and government users in the continental U.S., Alaska and Hawaii. Twenty-four transponders operate at 6/4 GHz. The new commsat, the first in a series of scheduled replacements for the GE network, features command encryption and both vertical and horizontal polarization. Onboard polarization switching allows the satellite to operate at other orbital positions to restore interruptions in multipoint distribution services. The box-shaped bus measures 2.5 m by 1.3 m by 1.6 m. Solar arrays, supplying 1,030 W at end of life, span 15.7 m when deployed. Liftoff weight was 1,169 kg; on-orbit weight is 670 kg. Satcom C-1 is stationed above 137 deg. w long., and has a 12-year design life.



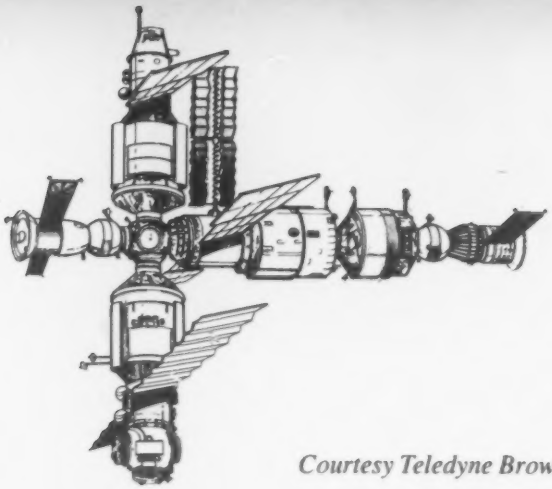
Satcom C-1 *Courtesy GE Astro Space*

GStar 4

Completing the GTE Spacenet communications satellite network, GStar 4 was tandem-launched aboard an Ariane 42P, 23:11, November 20. The fourth all Ku-band satellite in the network, GStar 4, stationed above 125 deg. w long., joins three GStars and three Spacenet satellites in geosynchronous orbit. Built by GE Astro Space, the satellite measures 2.75 m by 1.3 m by 1.6 m. Solar arrays spanning 14.3 m supply 1,352 W at end of life. GStar 4 weighed 1,295 at launch; 741 kg on orbit. The communications payload consists of 16 Ku-band transponders providing telephone, video and data service to commercial users in the continental United States, Alaska and Hawaii. A full frequency reuse capability allows uplink and downlink frequencies to be used twice. Beam switching enables users to fine-tune geographical service areas. GStar 4 has a 10-year life expectancy.

STS-35/Astro-1

Columbia lifted off from Kennedy Space Center Pad 39A at 06:49, December 2, with the long-delayed Astro-1 astronomy observatory in its payload bay. Columbia's 10th flight was commanded by Vance D. Brand and piloted by Guy S. Gardner. Jeffrey A. Hoffman, John M. Lounge and Robert A.R. Parker were mission specialists. Samuel T. Durrance and Ronald A. Parise were payload specialists. Orbiter/cargo weight was 121,183 kg at launch; total shuttle weight, 204,900 kg. Astro-1 consists of three ultraviolet instruments mounted in parallel on a Spacelab pallet system. The instruments, supplied by Johns Hopkins University, the University of Wisconsin and NASA Goddard SFC, studied quasars, galactic nuclei, supernova remnants, the polarization of ultraviolet light, and acquired images of faint objects. A separate X-ray telescope captured images of active galaxies, supernovae remnants and stars. Software problems with the instrument pointing system (IPS) were aggravated nine hours into the mission by a data display unit (DDU) failure. The DDU was the interface through which the astronauts commanded the IPS. A back-up DDU was used until it failed on mission day five, leaving the crew with no way to point the ultraviolet instruments. The X-ray telescope was not affected. The problem was circumvented by computer commands sent to the IPS from NASA Johnson combined with instrument commands radioed from NASA Marshall. STS-35 crew members used a joystick to fine-tune the pointing and hold to the target. The salvaged mission succeeded in making 400 observations of 135 objects. The Soviet Mir station was spotted by astronauts on two occasions, December 4, when Columbia orbited near it. STS-35 was cut short by one day due to threatening weather at the California landing site. Columbia's 8-day, 23-hr, 5-mn flight concluded on Edwards AFB runway 22, December 11 at 05:54.



Courtesy Teledyne Brown Engineering

Cosmonauts Alexander Viktorenko and Alexander Serebrov, aboard the Mir space station since September 7, completed five spacewalks during the first two months of 1990. A 2-hr, 56-mn excursion on January 7 enabled the cosmonauts to collect exposed sample materials for return to earth and install two star sensors on the Kvant 1 module. The sensors offer better control of Mir's new asymmetrical configuration resulting from the Kvant 2 addition in December. During a 2-hr 54-mn EVA on January 11, the pair replaced several more material samples with new ones for long-term exposure to space. On a third venture, lasting 3 hrs 2 mn on January 26, the crew demonstrated new closed system space suits and prepared to test the Soviet Ikar manned maneuvering unit. On February 1, Serebrov tested the "space motorcycle." Tethered to a docking device, he piloted the Ikar some 33 m from Mir during a 4-hr, 59-mn EVA. A second 3-hr, 45-mn MMU test with Viktorenko commenced February 5. After an active 166 days, 6 hrs, 58 mns in space, the cosmonauts returned to earth aboard Soyuz TM-8, landing 1,700 km southeast of Moscow at 04:36, February 19. An American crystal growth experiment, sponsored by Payload Systems Inc., was also returned at that time. The firm will apply the results of that 58-day microgravity flight to the design of new pharmaceuticals.

Soyuz TM-9

Anatoli Solovyov and Alexander Balandin arrived at Mir February 13, two days after an 06:16 liftoff from the Baikonur Cosmodrome. The departing TM-8 crew reported that three of the TM-9 transport's eight thermal blankets were damaged, a situation leading to two unscheduled spacewalks. Ground controllers feared that the torn insulation was blocking sensors used

to align the spacecraft at reentry, and that as exposure to the space vacuum degraded TM-9's temperature controls, condensation would cause an electrical short. The temperature was stabilized by maneuvering Mir to keep TM-9 facing the sun, but the blanket damage could not be mitigated without special tools and an EVA ladder to reach the impaired area. The materials arrived with the Kristall module, June 10. Kristall docked at the front longitudinal port of the Mir complex, and was moved to a radial port opposite Kvant 2 the next day. The cosmonauts began the repair mission July 17, exiting through the Kvant 2 hatch. The thermal problem was solved by stowing the torn blankets out of the sensor's line of sight, a laborious task that took six hours — near the limits of their space suits. Back in the Kvant 2 airlock, they discovered the outer door wouldn't close. Apparently, the chamber had not fully depressurized when they opened the hatch and its hinges were damaged. Solovyov and Balandin had to depressurize an adjoining compartment, move into it, then repressurize it to enter the station proper. By then almost seven hours had elapsed. On July 26, they reentered the open airlock to repair the buckled hinge. A short-term fix was accomplished during the 3-hr 31-mn spacewalk. The cosmonauts' 179-day, 1-hr, 18-mn mission ended August 9th when Soyuz TM-9 landed in Soviet Central Asia at 07:34.

Kristall

Mir's third expansion module, dedicated to materials processing, was launched from Baikonur aboard a Proton booster at 10:33, May 31. Kristall houses a Krater-5 electric furnace and Optizon beam installation unit; Zona-02 and 03 electric furnaces; Marina and Glazar-2 telescopes; and a biomedical research unit. The furnaces produce material for semiconductors; the telescopes monitor earth. Kristall is 11.9 m long, 4.35 m in diameter. Solar arrays span 36 m. Launch mass was 19,640 kg. Its main body is similar to Kvant 2, with a multiple docking port instead of an EVA airlock module. The docking system will host a future Buran visit. Kristall's planned June 6 docking was delayed until 10:47, June 10, by a malfunction in the orientation system. Kristall increases Mir's mass to 83 metric tons and restabilizes the station, thrown off kilter with the addition of Kvant 2.

Soyuz TM-10

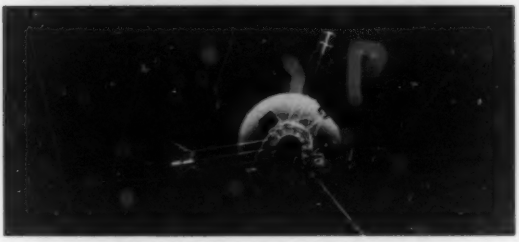
Mir's replacement crew, Gennedy Manakov and Gennedy Strekalov, were launched aboard Soyuz TM-10 from Baikonur, August 1 at 09:32. The craft and crew docked at the space station two days later. Unlike previous Soyuz transports, TM-10 remained docked at the rear of the complex throughout the mission. Visiting resupply craft, Progress M-4 and M-5, docked at Mir's front port. Progress M-4, arriving August 17, remained in Mir's vicinity for three days after undocking September 17, to allow the crew to photograph artificial plasmas created by an onboard experiment. Progress M-5, launched September 27, was the first to carry a small recoverable capsule able to return up to 150 kg of material to earth. The capsule, containing Kristall-produced materials, was recovered inside the Soviet Union November 28 at 11:04. Back at Mir, Manakov and Strekalov attempted to replace the damaged Kvant 2 hatch hinge in a 3-hr, 45-mn EVA, October 29. The operation was unsuccessful. Most of their time aboard Mir was spent with processing operations in Kristall. The cosmonauts returned to earth December 10, landing on the Kazakhstan steppe at 06:08 after 130 days, 20 hrs, 36 mns in space.

Soyuz TM-11

The first "paying passenger" to visit the Soviet space complex, Japanese journalist Toyohiro Akiyama, arrived at Mir with cosmonauts Musa Manarov and Viktor Afanasyev, December 4. The crew was launched aboard Soyuz TM-11 from Baikonur, December 2 at 08:13. Toyohiro's flight was sponsored by the Japanese TV station, TBS, and several corporations. While onboard he provided Japanese TV and radio audiences with real-time accounts of life in orbit, photographed environmental damage on earth and observed how tree frogs behaved in microgravity. Akiyama returned with the Soyuz TM-10 crew, December 10, after a 7-day, 21-hr, 55-mn flight. Manarov and Afanasyev remained aboard the station, continuing the smelting tasks, astronomy and geophysics studies begun by their predecessors. They are scheduled to return in May 1991.

Pioneer 6

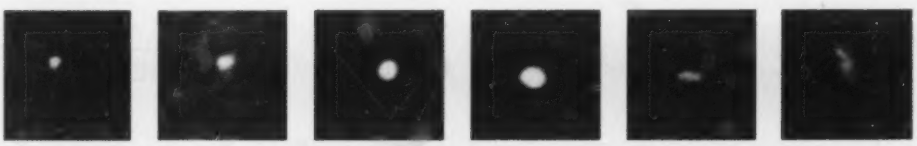
Pioneer 6, NASA's oldest operational spacecraft, celebrated 25 years of service, December 16. Launched in 1965 to study solar activity from a far-ranging elliptical orbit, the spacecraft has since circled the sun 29 times, traveled some 24.7 billion km and returned more than 15 billion bits of data. Pioneer 6 made the first detailed observations of the heliosphere, measured the tail of Comet Kohoutek and, working with other spacecraft, charted changes in the 11-year solar cycle. During the Apollo program the spacecraft warned of solar storms to protect the astronauts from radiation. Built by TRW Space & Technology group for a six-month mission, Pioneer 6 is today monitored intermittently due to the demands newer planetary explorers place on NASA's Deep Space Network. Three of Pioneer's six instruments have failed and its solar cells are degrading, but the transmitter continues to function at full power. Plasma and charged particle data is received and forwarded to scientists about twice a year. Pioneer 6 was tracked for two hours December 17 to mark its 25th anniversary.



Pioneer 11

Pioneer 11 crossed the orbit of Neptune, February 23, becoming the fourth spacecraft to exit the solar system. Neptune is currently the outermost planet, its orbit extending beyond Pluto. Launched April 6, 1973, on a 2.5-year mission to Jupiter, Pioneer 11 used the gas giant's gravity to slingshot it towards Saturn, serving as a pathfinder for the Voyager flybys. The spacecraft flew within 21,000 km of Saturn in 1979, returning the first close-up images of the planet and its rings. Pioneer's escape trajectory has taken it above the solar equatorial plane. From some 1.25 billion km above the ecliptic, the spacecraft discovered that many solar cosmic rays in the heliosphere originate in the interstellar gas. Scientists hoped that Pioneer 11 would join its fellow interstellar sojourners, Voyagers 1 and 2 and Pioneer 10, in the search for the heliopause. The Voyagers were the second and third spacecraft to leave the solar system; Pioneer 11's sister craft Pioneer 10 — both were built by TRW Space & Technology Group — was the first, crossing Neptune's orbit in 1983. Communications with Pioneer 11 were disrupted in October. The spacecraft was successfully switched from science to engineering mode, enabling technical data to reach earth, but with no further science coming, the craft may be retired in 1991.

Family Portrait



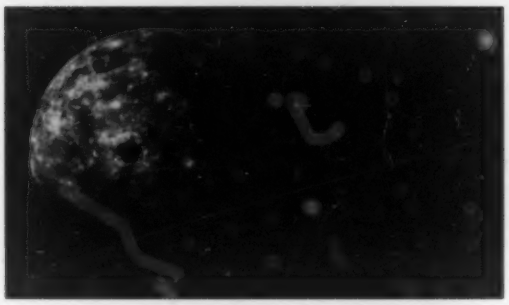
Venus *Earth* *Jupiter* *Saturn* *Uranus* *Neptune*

Voyager 1, 5.9 million km from the sun, traveling through interstellar space towards the heliopause, took one last look, February 13, at the solar system that spawned it. Voyager 1's position, 32 degrees above the ecliptic plane, gave it a better vantage point for the planetary family portrait than Voyager 2, also traveling into interstellar space after a grand tour of Jupiter, Saturn, Uranus and Neptune. Voyager 1, launched September 5, 1977, encountered Jupiter in 1979 and Saturn in 1980. The look back photos were

Courtesy JPL

captured during a four-hour imaging session. Mercury was too close to the sun, Mars was blotted out by solar light and Pluto was too far away to be seen. Because NASA's Deep Space Network was tracking Galileo and Magellan, Voyager's pictures were stored for later transmission in March. The instruments on both Voyagers have been turned off to save power. Scientists plan to maintain contact with both craft until their signals are too weak to hear — perhaps another 25 years.

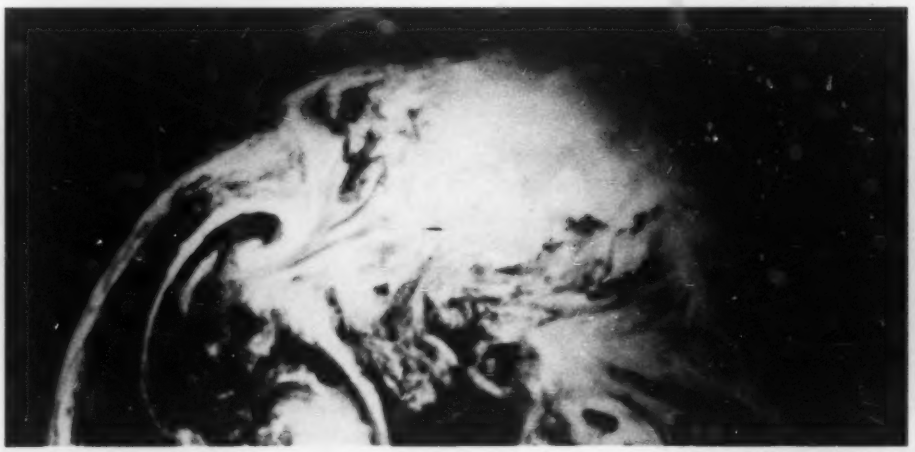
In hibernation since its 1986 rendezvous with Comet Halley, the **Giotto** spacecraft was reawakened and retargeted towards a July 1992 cometary encounter. Launched July 2, 1985, the European Space Agency probe dove within 605 km of Halley's nucleus as the comet passed 150,000 km from earth. Giotto suffered camera damage from the battering of cometary dust particles, but 70 percent of its instruments are still operational. The spacecraft was reactivated February 19 to assess its condition. The wake-up call, sent 100 million km through space, was answered at 15:06, two hours after the transmission began. Giotto was later declared healthy enough for a second mission. It will not return imagery, but its instruments are expected to provide significant measurements. In March, ground controllers began a series of maneuvers to align the craft for its reprise mission. On July 2 it passed within 22,000 km of earth, using its home planet for a gravity assisted boost towards Comet Grigg-Skjellerup. It was the first time earth's gravity was used as an interplanetary slingshot; although Galileo repeated the maneuver in December. Giotto is back in hibernation, awaiting its July 10, 1992, appointment.

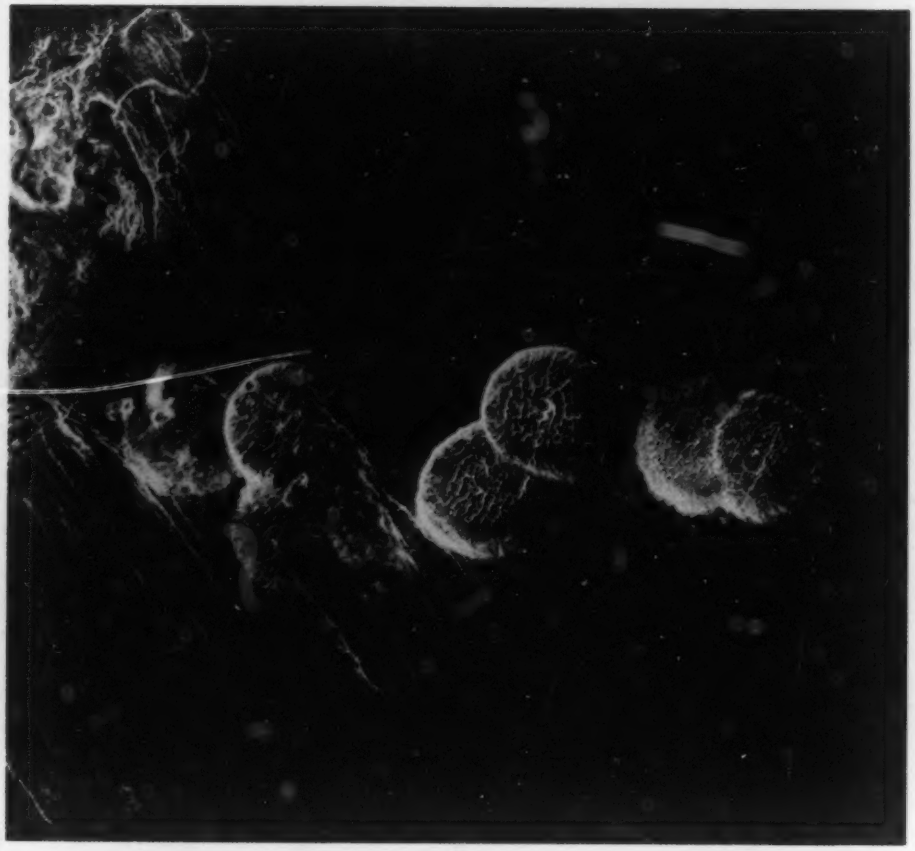


Courtesy JPL

The **Galileo** spacecraft swung by earth, December 8, in the second of three gravity assists altering its trajectory and increasing its speed towards a 1995 rendezvous with Jupiter. Galileo's first gravity boost was at Venus, where, passing within 16,000 km of its cloud tops, February 9, it gathered visible light and infrared images, and plasma data. The information was stored for transmission to earth during the December flyby. At 20:34, Galileo passed 950 km above the Atlantic Ocean, within 8 km of target and just 0.4 sec behind schedule. The spacecraft measured water in the upper atmosphere, studied the magnetic field and took infrared images of the southern hemisphere. Heading away, it took color pictures of the full disc every minute for 24 hours. It was the first time the earth and moon had been studied by a planetary probe, revealing how the planet would appear to an alien explorer. The spacecraft found an abundance of biological activity on earth, but no signs of intelligent life. Earth's gravity assist increased Galileo's speed from 67,240 to 78,860 mph. The craft is now enroute to an October 1991 flyby of the asteroid Gaspra. It will pass earth again for a final gravity assist in 1992. That flyby will increase its speed to 87,190 mph. Galileo, built by the Jet Propulsion Laboratory, will enter Jupiter orbit in December 1995.

Courtesy JPL





"Pancake" volcano domes on Venus *Courtesy JPL*

Magellan arrived in Venus orbit August 10, after an 83-second rocket burn altered its 160 million km, 15-month journey through space. Although the spacecraft's scheduled 243-day mapping mission got off to a shaky start, it has, since September 15, returned high-quality radar images of the terrain beneath Venus' dense clouds. Cast into a 297 by 8,463-km, 85.5-deg. polar orbit, Magellan circles Venus every three hours, mapping a 24 by 16,000-km swath of the planet's surface. On August 16th it gathered test pictures, but later that day suffered a communications outage lasting 15 hours. A second silence August 21 lasted 17 hours. The problem is suspected to fall within the Attitude and Articulation Control system. Controllers dispatched new software that automatically resets the system when anomalies occur. Images captured via the Hughes Aircraft Co. Synthetic Aperture Radar show evidence of vulcanism, tectonic movement, turbulent surface winds; hundreds of miles of lava channels and pancake-shaped domes. By year end Magellan had mapped 55 percent of Venus during 183 mapping days over 973 orbits. Built by Martin Marietta for JPL, Magellan is scheduled to operate for 2.5 years. The mission will continue as long as maneuvering fuel holds out.

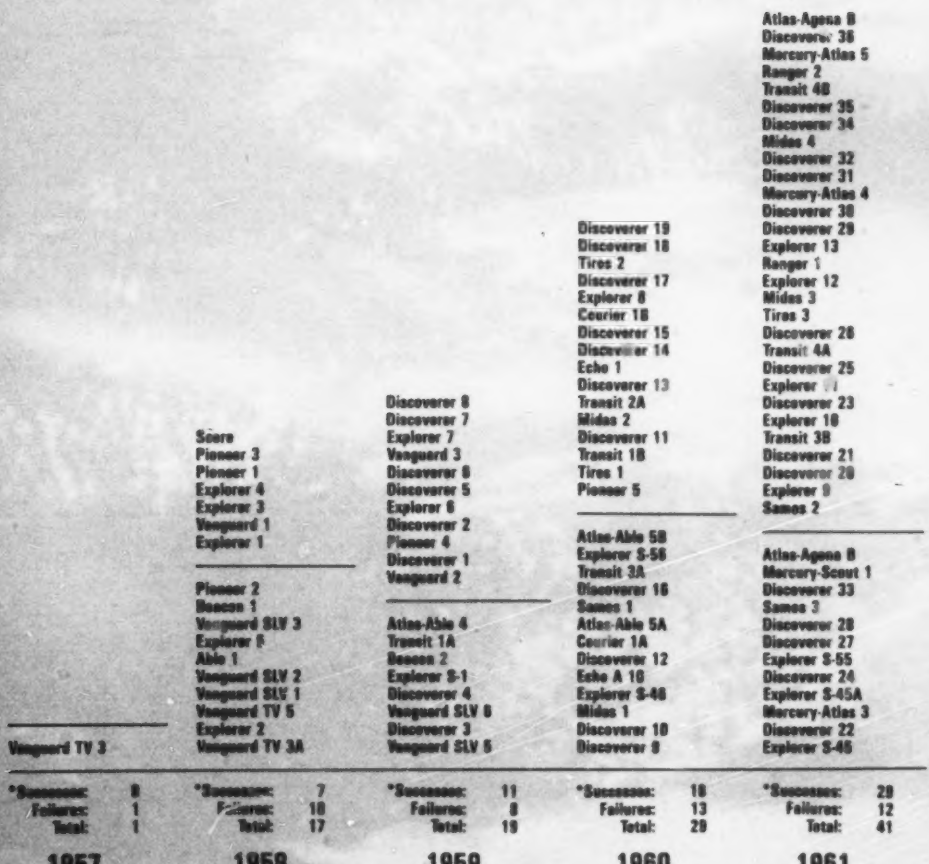
Box Score of U.S. Launches

Worldwide record of known successful U.S. launches

International payloads are listed when launched by U.S. booster

Classified U.S. payloads are listed by launch vehicle

*Payload(s) injected into orbit



1957	1958	1959	1960	1961
*Successes: 8	*Successes: 7	*Successes: 11	*Successes: 18	*Successes: 29
Failures: 1	Failures: 10	Failures: 8	Failures: 13	Failures: 12
Total: 1	Total: 17	Total: 19	Total: 29	Total: 41

Transit 5A
Explorer 16
Thor-Agena D
Relay 1
Thor-Agena D
Thor-Agena D
Thor-Agena B
Atlas-Agena B
Thor-Agena B
Anna 1B
Explorer 15
Starad
Ranger 5
Thor-Agena B
Mercury-Atlas 8
Explorer 14
Thor-Agena D
Alouette 1
Tiros 6
Thor-Agena B
Thor-Agena B
Thor-Agena B
Mariner 2
Scout
Atlas-Agena B
Thor-Agena D
Thor-Agena B
Thor-Agena B
Atlas-Agena B
Telstar 1
Thor-Agena D
Thor-Agena B
Tiros 5
Thor-Agena B
Atlas-Agena B
Thor-Agena B
Thor-Agena B
Mercury-Atlas 7
Thor-Agena B
Thor-Agena B
Atlas-Agena B
Ariel 1
Ranger 4
Thor-Agena B
Atlas-Agena B
Atlas-Agena B
OSO 1
Discoverer 36
Thor-Agena B
Mercury-Atlas 6
Tiros 4
Ranger 3

Atlas-Agena B
Mariner 1
Scout
Anna 1A
Solrad 4B
Composite 1
Discoverer 37

1962

*Successes: 62
Failures: 7
Total: 69

TAT-Agena D
Tiros 8
Explorer 19
Atlas-Agena B
Thor-Able Star
Thor-Agena D
Atlas-Centaur 2
Explorer 18
TAT-Agena D
Atlas-Agena D
Vela 1 & 2
Thor-Able Star
TAT-Agena D
Atlas-Agena D
Thor-Agena D
TAT-Agena D
TAT-Agena D
Syncom 2
Atlas-Agena B
Thor-Agena D
Atlas-Agena D
TAT-Agena B
Geophysical Research Satellite
TAT-Agena D
Tiros 7
Scout
Thor-Agena D
TAT-Agena D
TAT-Agena D
Mercury-Atlas 9
Atlas-Agena B
Telstar 2
Explorer 17
Thor-Agena D
Scout
Syncom 1
Thor-Agena D
Thor-Agena D

Thor-Agena D
Scout
Atlas-Agena B
Thor-Agena D
Scout
Scout
TAT-Agena D
TAT-Agena D

1963

*Successes: 38
Failures: 8
Total: 46

TAT-Agena B
Explorer 28
TAT-Agena D
San Marco 1
Thor-Able Star
Atlas Centaur 4
Ironstage
Atlas-Agena B
Mariner 4
Explorer 24 & 25
TAT-Agena D
Explorer 23
Mariner 3
TAT-Agena D
TAT-Agena D
Atlas-Agena D
TAT-Agena D
Explorer 22
Thor-Able Star
TAT-Agena B
Explorer 21
Atlas-Agena D
Saturn SA-7
TAT-Agena D
OGO 1
Nimbus 1
Explorer 2[illegible]
TAT-Agena D
Syncom 3
Atlas-Agena D
TAT-Agena D
Ranger 7
Vela 3 & 4
TAT-Agena D
Atlas-Agena D
TAT-Agena D
TAT-Agena D
Thor-Agena D
TAT-Agena D
TAT-Agena D
Scout
Saturn SA-6
Atlas-Agena D
TAT-Agena D
Atlas-Agena D
Gemini-Titan 1
Ariel 2
Atlas-Agena D
TAT-Agena D
Atlas-Agena D
TAT-Agena D
Ranger 8
Saturn SA 5
Echo 2
Relay 2
Thor-Agena D
TAT-Agena D

Atlas-Agena B
Titan IIIA
Atlas Centaur
Environmental Sciences Research Satellite
Thor-Able Star
TAT-Agena D
Beacon-Explorer A

1964

*Successes: 57
Failures: 7
Total: 64

TAT-Agena D
Scout
LES 3, 4 et. al.
Pioneer 6
Gemini 6
TAT-Agena D
FR 1
Gemini 7
Alouette 2 et. al.
Explorer 30
Atlas-Agena D
Explorer 29
TAT-Agena D
OV2 1, LCS 2
OGO 2
TAT-Agena D
OV1 2
Atlas-Agena D
TAT-Agena D
Thor-Altair
Gemini 5
TAT-Agena B
Sorcal et. al.
Atlas-Centaur 5
Secor 5
Atlas-Agena D
Pegasus 3
Vela 5 & 6
TAT-Agena D
TAT-Agena B
Tiros 10
Atlas-Agena D
Thor-Able Star
Titan IIC
TAT-Agena D
Gemini 4
Explorer 28
Atlas-Agena D
Pegasus 2
Thor-Altair
TAT-Agena D
LES 2, ECS 1
TAT-Agena D
Explorer 27
Atlas-Agena D
Early Bird
Snapshot
TAT-Agena D
Gemini 3
Ranger 9
Thor-Altair
Atlas-Agena D
Thor-Able Star
GGS 2 & 3 et. al.
TAT-Agena D
Ranger 8
Pegasus 1
LES 1
OSO 2
Atlas-Agena D
Tiros 9
Thor-Altair
TAT-Agena D

Gemini 6 Target
Thor-Agena D
OSO C
Atlas-Agena D
OV1 3
Atlas Centaur
OV1 1

1965

*Successes: 63
Failures: 7
Total: 70

TAT-Agena D
Biosatellite 1
Titan IIIB-Agena B
OV1 9 & 10
ATS 1
Atlas-Agena D
Gemini 12
Gemini 12 Target
TAT-Agena D
Lunar Orbiter 2
OV4 3 et. al.
Atlas-Agena D
OV3 2
Atlas Centaur 9
Intelsat IIA
Atlas-Agena B
EGRS-6
ESSA 3
Titan IIIB-Agena D
TAT-Agena D
Surveyor 2
Atlas-Agena D
Thor-Burner II
Gemini 11
Gemini 11 Target
[illegible] 15
[illegible]out
Pioneer 7
Atlas-Agena D
Lunar Orbiter 1
Thorad-Agena D
OV3 3
Titan IIIB-Agena D
Gemini 10
Gemini 10 Target
OV1 8
Atlas-Agena D
Saturn I
Explorer 33
Pegasus
TAT-Agena D
IDCSP 1-7, GGTS 1
OV3 4
Secor 6, ERS 18
OGO 3
Atlas-Agena D
Gemini 9
Gemini 9, Target B
Surveyor 1
Explorer 32
TAT-Agena D
Scout
Nimbus 2
Atlas-Agena D
OV3 1
Atlas-Agena D
OAO 1
Atlas Centaur
TAT-Agena D
Thor-Altair
OV1 4 & 5
Scout
Atlas-Agena D
Gemini 8
Gemini 8 Target
TAT-Agena D
ESSA -2
Atlas-Agena D
TAT-Agena D
ESSA 1
TAT-Agena D
Scout
Atlas-Agena [illegible]

IDCSP (8 satsoems)
Gemini 9 Target A
TAT-Agena D
Thor-Altair

*Successes: 73
Failures: 4
Total: 77

1966

1967	1968	1969	1970	1971
Pioneer 8	Apollo 8	Thorad-Agena D	Explorer 42	Intelsat IV F-3
LTTAT-Agena D	Intelsat IIIB	Skynet 1	NOAA-1	Thorad-Agena D
Titan IIIB-Agena D	ESSA 8	Apollo 12	Thorad-Agena D	Ariel 4
OV3 6	LTTAT-Agena D	Azur 1 (GRS A)	OFO 1, RM	Explorer 46
ESSA 6	OAO 2	Titan IIIB-Agena D	Titan IIIC	DSCS 1, 2
Apollo 4	MEOS 1	Boreas (ESRO 1B)	Titan IIIB-Agena D	Titan IIIB-Agena D
Surveyor 6	Titan IIIB-Agena D	LTTAT-Agena D	Thor-Burner II	NOAA 2
ATS 3	Pioneer 9, TETR 2	LTTAT-Agena D	Thor-Agena D	Space Test Program
LTTAT-Agena D	Titan IIIB-Agena D	Titan IIIB-Agena D	Scout	Thor-Burner II
Titan IIIB-Agena D	TAT-Agena D	ATS 5	Thorad-Agena D	OSO 7, TETR 4
OSO 4	Thor-Burner II	OSO 6, PAC 1	Skynet II	LTTAT-Agena D
Thor-Burner II	Apollo 7	LTTAT-Agena D	Titan IIIB-Agena D	EOLE 1
Intelsat IID	LTTAT-Agena D	Intelsat IIIE	Intelsat III F-8	Titan 111B-Agena D
Scout	Aurorae (ESRO 1A)	LTTAT-Agena D	Titan IIIB-Agena D	OV1-20 et. al.
Titan IIIB-Agena D	OV2 5 et. al.	Thor-Burner II	Titan IIIB-Agena D	Apollo 15, P&F
LTTAT-Agena D	TAT-Agena D	Apollo 11	Intelsat III F-7	Thorad-Agena D
Lunar Orbiter 5	Titan IIIB-Agena D	Biosatellite 3	Titan IIIB-Agena D	Explorer 44
OGO 4	ESSA 7	Explorer 41	Apollo 13	Titan IIID
OV1 12 & 98	ATS 4	OGO 6	Vela 11, 12	LTTAT-Agena D
TAT-Agena D	Explorer 39 & 40	Titan IIIB-Agena D	Nimbus 4, TOPO 1	Mariner 9
Explorer 35	LTTAT-Burner II	Vela 9, 10 et. al.	NATO 1	Titan IIIC
Surveyor 4	Titan IIIB-Agena D	Intelsat IIID	Thorad-Agena D	San Marco 3
IDCSP 10-18 et. al.	Atlas-Agena	Apollo 10	Thor-Burner II	Titan IIIB-Agena D
Sonar 9, Aurora 1	OV1 15 & 16	LTTAT-Agena D	SERT 2	ISIS 2
Titan IIIB-Agena D	Explorer 38	Titan IIIB-Agena D	ITOS 1, Oscar 5	LTTAT-Agena D
LTTAT-Agena D	LTTAT-Agena D	Nimbus 3, Secor 13	Intelsat III F-8	Titan IIIB-Agena D
Mariner 5	IDSCS 19-26	Atlas-Agena D	Titan IIIB-Agena D	Explorer 43
Atlas-Agena D	Titan IIIB-Agena D	Mariner 7		Thor-Burner II
OGSE 4, 5 et. al.	Thor-Burner II	LTTAT-Agena D		NATO 2
Explorer 34	Iris (ESRO 2B)	OV1 17,18 19 & 17A		Apollo 14
Atlas-Agena D	LTTAT-Agena D	Titan IIIB-Agena D		Intelsat IV F-2
Scout	Titan IIIB-Agena D	Apollo 9		Titan IIIB-Agena D
LTTAT-Agena D	OV1 13 & 14	ESSA 9		
Ariel 3	Apollo 6	Mariner 8		
Lunar Orbiter 4	LTTAT-Agena D	Tacsat 1		
Vela 7, 8 et. al.	Titan IIIB-Agena D	Intelsat IIIC		
San Marco 2	Explorer 37	LTTAT-Agena D		
ESSA 5	OGO 5	ISIS 1		
Surveyor 3	Scout	Titan IIIB-Agena D		
Scout	LTTAT-Agena D	OSO 5		
ATS 2	Apollo 5			
TAT-Agena D	Titan IIIB-Agena D			
Intelsat IIC	TAT-Agena D			
OSO 3	Explorer 38			
Titan IIIC-Agena D	Surveyor 7			
TAT-Agena D				
Thor-Burner II				
Lunar Orbiter 3				
Atlas-Agena D				
ESSA 4				
IDCSP 8-15				
TAT-Agena D				
Intelsat IID				
ESRO 2A	Intelsat IIIA	Pioneer E, TETR C	OAO 8	Atlas Agena D
Titan IIIB-Agena D	OV5 8 et. al.			PAET Probe
OV3 5	Nimbus B, Sesar 10			Mariner H
				Thorad-Agena D
*Successes: 58	*Successes: 45	*Successes: 40	*Successes: 29	*Successes: 32
Failures: 3	Failures: 3	Failures: 1	Failures: 1	Failures: 4
Total: 61	Total: 48	Total: 41	Total: 30	Total: 36

1972	1973	1974	1975	1976
Titan 3B-Agena				
Atlas-Agena				
Aeros				
Nimbus 5				
Apollo 17				
ESRO IV				
Explorer 48				
ANIK 1				
Thor-Burner II	Explorer 51	Symphonie	Titan IIIC	Titan IIID
NOAA 2, OSCAR 6	DSCS II-B3, B4	Helios	RCA Satcom 1	Marisat 3
Titan IIID	Skylab 4	Skynet 2B	Titan IIID	Titan IIIB-Agena
Atlas F-Burner II	Titan IIID	Intelsat IV F-8	Explorer 55	AMS 1
Explorer 47	NOAA 3	NOAA	GOES 1	TIP 3
Triad OI-1	Mariner 10	Titan IIID	TIP 2	Satellite Data Sys. 2
Titan IIIB-Agena	Transit	Ariel 5	Titan IIIB	NOAA
OAO 3	Explorer 50	Westar B	Explorer 54	Comstar 2
Explorer 46	Titan IIIB-Agena D	AMS	Intelsat IVA F-1	Pelepe 1
ERTS 1	Intelsat IV F-7	Titan IIIB-Agena	Viking 2	Titan IIID
Titan IIID	Titan IIIB-Agena D	Thor-Burner IIA	Symphonie B	Titan IIIC
Intelsat IV F-5	Thor-Burner II	Aeros 2	Viking 1	Marisat 2
Thorad-Agena	Skylab 3	Timation 3	COS B	Titan IIIB
Thorad-Agena	Titan IIID	Titan IIIB-Agena	Apollo 18	P76-5
Apollo 16, P&F	Titan IIIC	Hawkeye	OSO 8	Comstar 1
Thor-Burner II	Explorer 49	ATS 6	Atlas-Agena	Lageos 1
Titan IIIB/Agena	Skylab 2	SMS 1	Nimbus 6	Atlas
TD 1A	Titan IIIB-Agena D	Westar A	SSU 1	Auto IIIA
Pioneer 10	Skylab 1	Titan IIID	DMSP	RCA Satcom 2
Titan IIIC	Anik 2	Thor-Burner IIA	Intelsat IV F-1	Titan IIIB-Agena D
HEOS A2	Pioneer 11	UK X4 (Miranda)	DSCS II-B5, B6	Titan IIIC
Intelsat F IV	Titan IIID	San Marco 4 (C2)	ANIK 3	Marisat 1
Titan IIID	Atlas-Agena D	Titan IIIB-Agena	Explorer 53	Thor-Burner 2
		Skynet 2A	Titan IIIB	Intelsat IVA F-3
Titan IIIB-Agena	ITOS-E		GEOS 3	CTS
Titan IIIB-Agena	Titan IIIB-Agena D	Viking Proof Test	Titan IIIB	Helios 2
			SMS 2	
			Landsat 2	
			Explorer	
			Atlas F	
			Intelsat IV F-6	
*Successes: 31	*Successes: 23	*Successes: 24	*Successes: 25	*Successes: 28
Failures: 2	Failures: 2	Failures: 1	Failures: 3	Failures: 0
Total: 33	Total: 25	Total: 25	Total: 31	Total: 28

1977	1978	1979	1980	1981
Sakura	Anik 4			Intelsat V F-3
Atlas-Agena D	DSCS II F			RCA-Satcom IIIR
NOSS-2	GPS-4			Columbia (STS-2)
Meteosat 1	NATO IIIC			Titan IIIC
Trans.sat	NEAO 2			SME and UOSAT
ISEE 1 & 2	Nimbus 7/Comsa			SBS 2
Titan IIIB	Tiros N			Titan IIID
Voyager 1	GPS 3			FLTSATCOM 5
Sirio	ISEE 3			Dynamic Explorer 1 & 2
Voyager 2	Pioneer Venus/Multiprobe			NOAA 7
NEAS-1	Titan IIIB-Agena D			Intelsat V F-1
Himawari (GMS-1)	GEOS 2			GOES 5
Titan IIID	Comstar 3			Nova 1
NTS-2	Sensat 1			Titan IIIB-Agena D
GOES-2	GOES 3			Columbia (STS-1)
DMSP	Titan IIID			Titan IIIC
Intelsat IVA F-4	Titan IIIC			Titan IIIB-Agena D
Atlas-Agena	Pioneer Venus/Orbiter			Comstar D-4
DSCS II	NDS 2	Satcom 3		
SEDS	DTS-2	DSCS II		
Titan IIIB	DMSP	Magsat		
Pulsar 2	NOMM	Titan III C	Titan IIIB-Agena	
Titan IIIC	YURI	HEAO 3	Intelsat V F-2	
Nato IIIB	NOAA 6	Westar 3	SBS-1	
	Intelsat IVA F-6	NOAA 7	FLATSATCOM 4	
	Titan IIID	Titan IIIC	GOES 4	
	Landsat 3/Oscar 8	DMSP	Titan IIID	
	Titan IIIB-Agena 4	UK 6	NOAA 6(7)	
	NSD-1	Titan IIIB	GPS-6	
	FLTSATCOM 1	FLTSATCOM 2	Atlas F	
	NUE	Titan IIID	Solar Max	
	Intelsat IVA F-3	P78-1	GPS-5	
		SAGE	Titan IIID	
Intelsat IVA		SCATHA	FLTSATCOM 3	
DTS	DSCS II			NAVSTAR GPS
*Successes: 24	*Successes: 32	*Successes: 11	*Successes: 13	*Successes: 10
Failures: 2	Failures: 1	Failures: 0	Failures: 0	Failures: 1
Total: 29	Total: 33	Total: 16	Total: 13	Total: 19

1982	1983	1984	1985	1986
Atlas E	STS-9	Titan 34D	Scout	
Titan IID	Atlas E	NOAA-9	STS 61-B	
STS-5	Galaxy 2	Titan 34D	STS 61-A	
DSCS II-F16,	RCA Satcom VII	Nato 3D	Navstar 11	
DSCS III-A1	STS-8	STS 51-A	STS 51-J	
RCA Satcom V	Titan IIIB-Agena D	Nova 3	Intelsat VA F-12	
Intelsat V F-5	Telstar 301 (J-1)	STS 41-G	STS 51-I	
Anik D-1	Atlas E	Galaxy 3	Scout	
Landsat 4	Galaxy 1	Navstar 10	STS 51-F	
STS 4	Scout	STS 41-D	Intelsat VA F-11	FLTSATCOM 7
Westar V	Titan 34D	Titan IIIB	STS 51-G	Polar BEAR
Titan IID	STS-7	Anopts 1,2,3	STS 51-B	NOAA-10
Insat 1A	Atlas H	Titan 34D	STS 51-D	Delta
STS-3	Exosat	Navstar 9	Intelsat VA F-10	Atlas H
Titan IIC	Intelsat V F-6	Intelsat VA F-8	Gorcat	STS 61-C
Intelsat V F-4	GOES 6	Titan IIIB	Titan IIIB	
Westar IV	Titan IIIB	Titan 34D	STS 51-C	
Titan III	RCA Satcom VI	STS 41-C		GOES 7
RCA Satcom IV	STS-6	Landsat 5		Titan 34D
	NOAA 8	Atlas H	Titan 34D	STS 51-L
	Atlas H	STS 41-B		
	IRAS	Titan 34D		
*Successes: 10	*Successes: 22	*Successes: 22	*Successes: 17	*Successes: 6
Failures: 0	Failures: 0	Failures: 0	Failures: 1	Failures: 3
Total: 10	Total: 22	Total: 22	Total: 18	Total: 9

Titan 34D
Titan 34D
Oscar 31, 32
DMSP
Atlas H
Palapa B2P
GOES 7
Titan IIIB
FLTSATCOM 6
*Successes: 8
Failures: 1
Total: 9
1987
STS-27
Titan 34D
STS-26
NOAA 11
Titan II
Titan 34D
Scout
Nova 2
Scout
SM-D
Delta
DMSP
*Successes: 12
Failures: 0
Total: 12
1988
GPS 2-5
STS-33
COBE
GPS 2-4
STS-34
FltSatCom 8
Titan 2
Titan 34D
Marcopolo 1
GPS 2-3
STS-28
Titan 4
GPS 2-2
Titan 34D
STS-30
Delta
STS-29
GPS 2-1
*Successes: 16
Failures: 0
Total: 16
1989
STS-35
DMSP
GPS 2-10
STS-38
Titan 4
Inmarsat 2-1
STS-41
GPS 2-9
Marcopolo 2
GPS 2-8
CRRES
Intelsat 6 F4
Ineot 1B
Titan 4
Scout
Scout
STS-31
Palapa B-2R
Atlas E
Pegasus
GPS 2-7
Intelsat 6 F3
STS-36
LACERIME
GPS 2-6
STS-32
Skynet 4A/UFOsat
*Successes: 27
Failures: 0
Total: 27
1990

STS Payload Deployment Record

1982

Anik C3 by PAM-D (STS-5)
SBS 3 by PAM-D (STS-5)

Successes:	2
*Failures:	0
Total:	2

1983

Insat 1B by PAM-D (STS-6)
SPAS by RMS (STS-7)
Palapa B1 by PAM-D (STS-7)
Anik C2 by PAM-D (STS-7)
TDRS 1 by IUS (STS-6)[1]

Successes:	4
*Failures:	1
Total:	5

1984

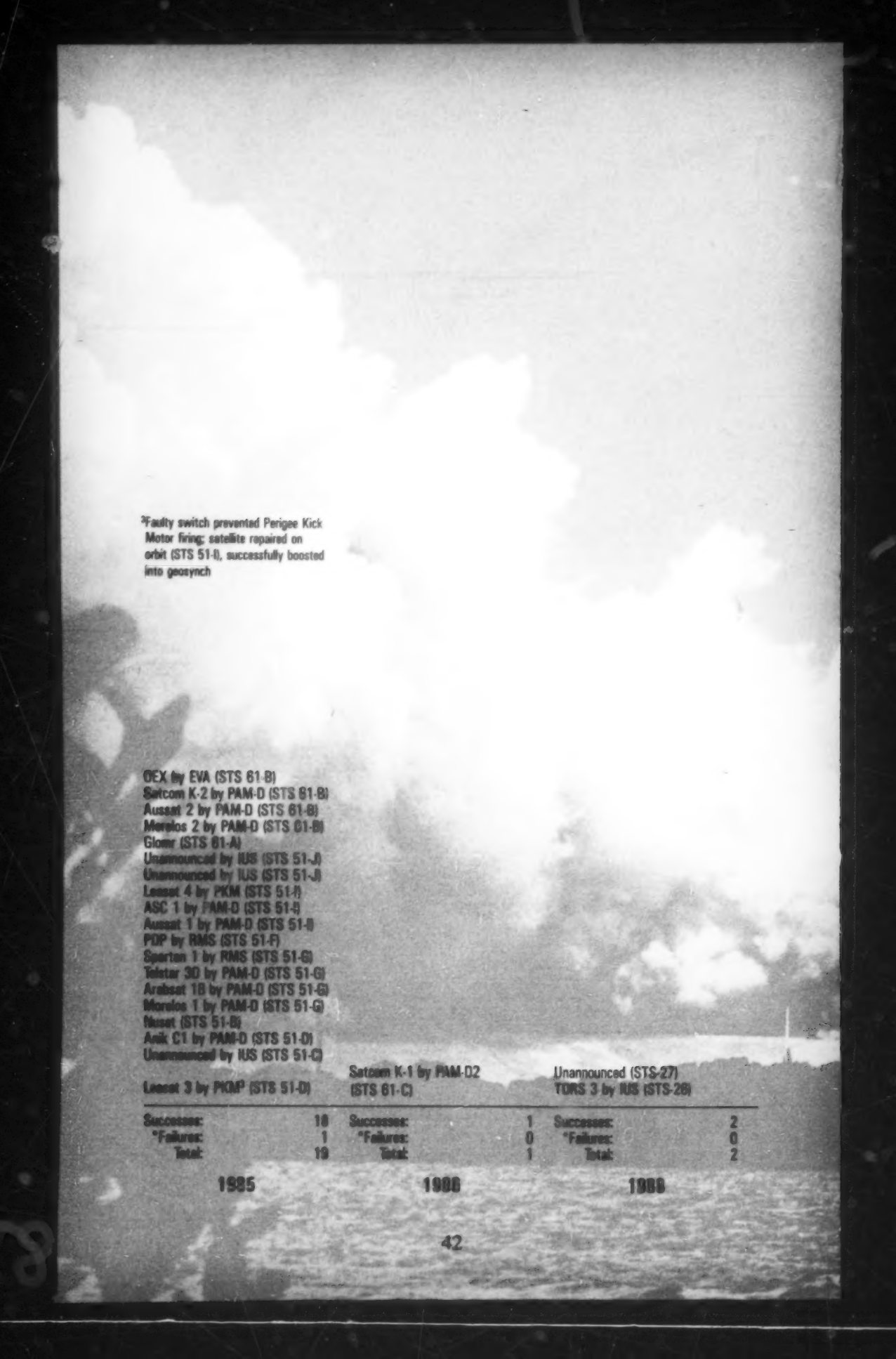
Leasat 2 by PKM (STS 51-A)
Anik D2 by PAM-D (STS 51-A)
ERBS by RMS (STS 41-G)
Telstar 3C by PAM-D (STS 41-D)
Leasat 1 by PKM (STS 41-D)
SBS 4 by PAM-D (STS 41-D)
LDEF by RMS (STS 41-C)
IRT (STS 41-B)
Palapa B2 by PAM-D (STS 41-B)[2]
Westar VI by PAM-D (STS 41-B)[2]

Successes:	8
*Failures:	2
Total:	10

[1]IUS failure cast TDRS into incorrect orbit; satellite subsequently boosted to geosynchronous orbit using its own thrusters

[2]Perigee Kick Motor failure. Satellites returned to earth via STS 51-A

*Desired orbit not achieved



[2]Faulty switch prevented Perigee Kick Motor firing; satellite repaired on orbit (STS 51-I), successfully boosted into geosynch

OEX by EVA (STS 61-B)
Satcom K-2 by PAM-D (STS 61-B)
Aussat 2 by PAM-D (STS 61-B)
Morelos 2 by PAM-D (STS 61-B)
Glomr (STS 61-A)
Unannounced by IUS (STS 51-J)
Unannounced by IUS (STS 51-J)
Leasat 4 by PKM (STS 51-I)
ASC 1 by PAM-D (STS 51-I)
Aussat 1 by PAM-D (STS 51-I)
PDP by RMS (STS 51-F)
Spartan 1 by RMS (STS 51-G)
Telstar 3D by PAM-D (STS 51-G)
Arabsat 1B by PAM-D (STS 51-G)
Morelos 1 by PAM-D (STS 51-G)
Nusat (STS 51-B)
Anik C1 by PAM-D (STS 51-D)
Unannounced by IUS (STS 51-C)
Leasat 3 by PKM[2] (STS 51-D)

Successes:	18
*Failures:	1
Total:	19

1985

Satcom K-1 by PAM-D2 (STS 61-C)

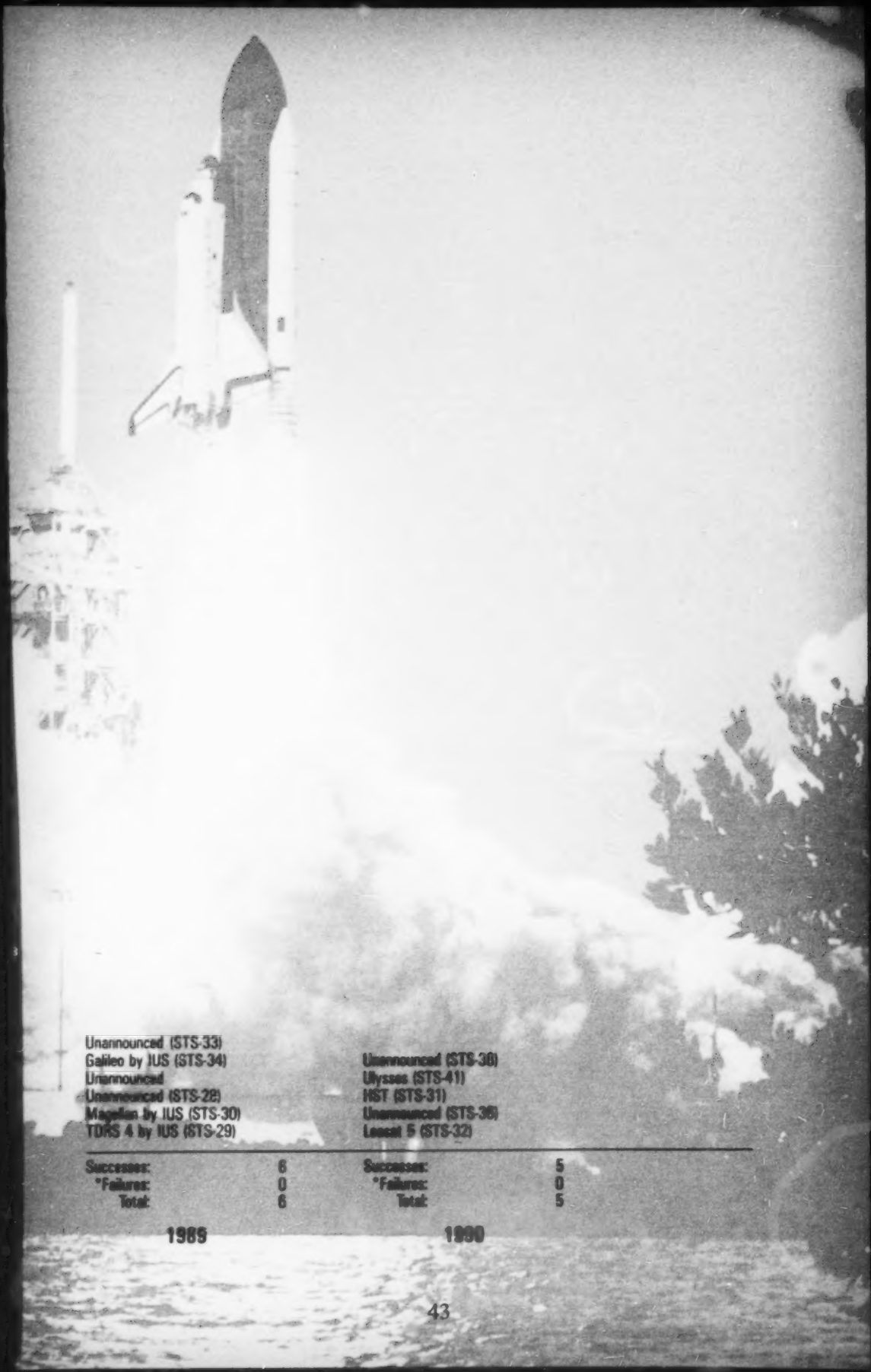
Successes:	1
*Failures:	0
Total:	1

1986

Unannounced (STS-27)
TDRS 3 by IUS (STS-28)

Successes:	2
*Failures:	0
Total:	2

1989

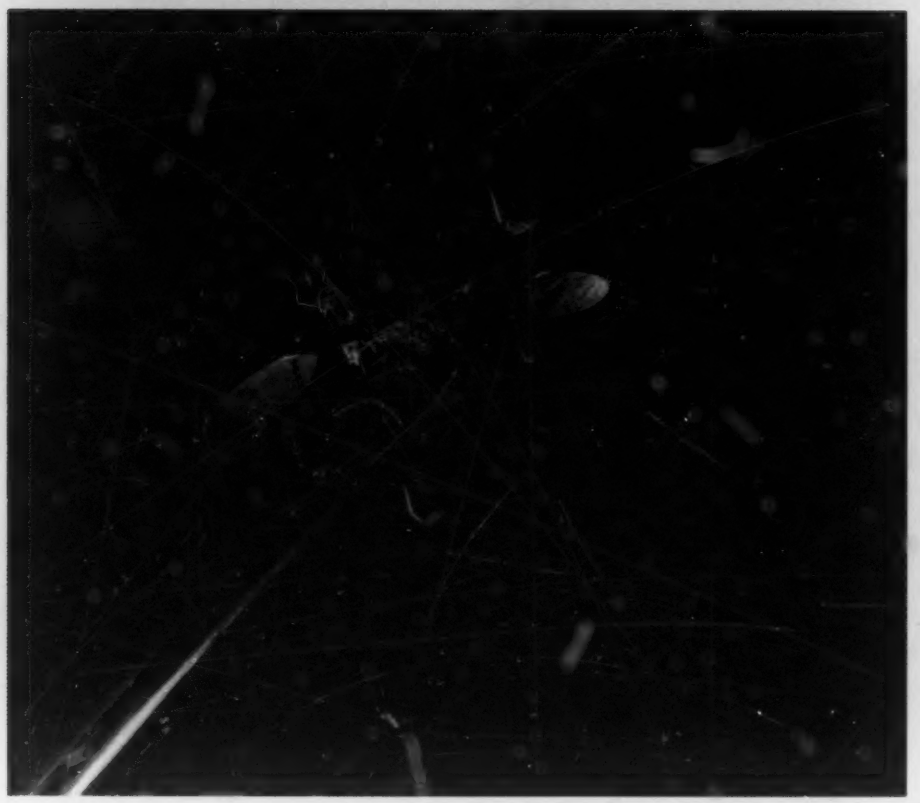


Unannounced (STS-33)	
Galileo by IUS (STS-34)	Unannounced (STS-38)
Unannounced	Ulysses (STS-41)
Unannounced (STS-28)	HST (STS-31)
Magellan by IUS (STS-30)	Unannounced (STS-36)
TDRS 4 by IUS (STS-29)	Lacsat 5 (STS-32)

Successes:	6	Successes:	5
*Failures:	0	*Failures:	0
Total:	6	Total:	5

1989 **1990**

Payloads in Orbit



Argentina	1	Japan	44
Australia	4	Luxembourg	1
Brazil	3	Mexico	2
Canada	14	NATO	6
ESA	20	PRC	11
France	18	Saudi Arabia	2
France/FRG	2	Spain	1
FRG	10	Sweden	2
India	8	UK	16
Indonesia	5	US	584
ITSO	39	USSR	1,177
Italy	1		
Total			**1,971**

As of December 31, 1990

Year	USSR	US†	France	Australia	China	Japan	UK	Europe**	India	Israel	Total
1957	2										2
1958	1	7									8
1959	3	11									14
1960	3	16									19
1961	6	29									35
1962	20	52									72
1963	17	38									55
1964	30	57									87
1965	48	63	1								112
1966	44	73	1								118
1967	66	58*	2	1							127
1968	74	45									119
1969	70	40									110
1970	81	29*	2		1	1					114
1971	83	32*	1		1	2	1				120
1972	74	31*				1					106
1973	86	23									109
1974	81	24*				1					106
1975	89	28*	3		3	2					125
1976	99	26			2	1					128
1977	98	24				2					124
1978	88	32			1	3					124
1979	87	16				2		1			106
1980	89	13				2			1		105
1981	98	18			1	3		2	1		123
1982	101	18			1	1					121
1983	98	22‡			1	3		2‡	1		127
1984	97	22			3	3		4			129
1985	98	17			1	2		3			121
1986	91	6			2	2		2			103
1987	95	8			2	3		2			110
1988	90	12*			4	2		7		1	116
1989	74	18				2		7			101
1990	75	27			5	3		5		1	116
Total	**2,256**	**935**	**10**	**1**	**28**	**41**	**1**	**35**	**3**	**2**	**3,312**

* Italy has launched nine spacecraft from its San Marco platform. U.S. Scout rockets were used for these launches, so NASA includes them in the U.S. launch total.

** Launches through March 1984 were ESA sponsored. Arianespace, a private company jointly held by European companies, has had launch responsibility since May of that year.

† Does not include payloads launched from space shuttle

‡ ESA launch from WSMC used U.S. Delta 3914 and is included in U.S. total

Satellites Reported Decayed in 1990

Int'l Desig.	Satellite	Decay Date	Launch Date
1963 022A	Transit 5A3	8/3	6/16/63
1965 014A	Kosmos 58	2/25	2/26/65
1965 112A	Kosmos 103	1/2	12/28/65
1968 017A	Explorer 37	11/16	3/5/68
1968 070A	Kosmos 236	3/4	8/27/68
1970 064A	Kosmos 358	6/26	8/20/70
1971 012E	Calsphere 5	1/7	2/17/71
1975 121A	Molniya 2-15	6/11	12/17/75
1976 041A	Molniya 3-5	4/14	5/12/76
1978 009A	Molniya 3-9	4/24	1/24/78
1979 047A	Ariel 6	9/23	6/2/79
1983 027A	Kosmos 1450	5/30	4/6/83
1983 033A	Rohini 3	4/19	4/17/83
1984 007A	Kosmos 1534	9/20	1/26/84
1984 034B	LDEF*	1/20	4/6/84
1984 127A	Kosmos 1615	4/15	12/20/84
1985 018A	Kosmos 1631	12/8	2/27/85
1988 045A	Kosmos 1949	4/23	5/28/88
1988 065A	Kosmos 1960	4/9	7/28/88
1989 071A	Soyuz TM-8	2/19	9/5/89
1989 088A	Kosmos 2049	6/19	11/17/89
1989 095A	Kosmos 2052	1/24	11/30/89
1989 099A	Progress M-2	2/9	12/20/89
1990 002A	STS-32	1/20	1/9/90
1990 003A	Kosmos 2055	1/29	1/17/90
1990 009A	Kosmos 2057	3/19	1/25/90
1990 012A	Kosmos 2059	11/12	2/6/90
1990 014A	Soyuz TM-9	8/9	2/11/90
1990 019A	STS-36	3/4	2/28/90
1990 020A	Progress M-3	4/28	2/28/90
1990 024A	Kosmos 2062	4/5	3/22/90
1990 027A	Ofeq 2	7/9	4/3/90
1990 032A	Foton 3	4/27	4/11/90
1990 033A	Kosmos 2072	11/21	4/13/90
1990 035A	Kosmos 2073	4/28	4/17/90
1990 037A	STS-31	4/29	4/24/90
1990 041A	Progress 42	5/27	5/5/90
1900 042A	Kosmos 2077	7/4	5/7/90
1990 044A	Kosmos 2078	6/28	5/15/90
1990 047A	Resurs-F6	6/14	5/29/90

Int'l Desig.	Satellite	Decay Date	Launch Date
1990 053A	Kosmos 2083	7/3	6/19/90
1990 059A	Badr-1	12/8	7/16/90
1990 060A	Resurs-F7	8/16	7/17/90
1990 062A	Kosmos 2086	8/3	7/20/90
1990 067A	Soyuz TM-10	12/10	8/1/90
1990 069A	Kosmos 2089	10/1	8/3/90
1990 072A	Progress M-4	9/20	8/15/90
1990 073A	Resurs-F8	9/1	8/16/90
1990 080A	Kosmos 2099	9/14	8/31/90
1990 082A	Resurs-F9	9/21	9/7/90
1990 085A	Progress M-5	11/28	9/27/90
1990 087A	Kosmos 2101	11/30	10/1/90
1990 089A	PRC 33	10/23	10/5/90
1990 090A	STS-41	10/10	10/6/90
1990 092A	Kosmos 2102	12/12	10/16/90
1990 097A	STS-38	11/20	11/15/90
1990 098A	Kosmos 2104	12/4	11/16/90
1990 106A	STS-35	12/11	12/2/90

*LDEF Plucked from a decaying orbit by STS-32, the Long Duration Exposure Facility (LDEF) returned to earth January 20. The 9,691-kg, 9 x 4-m laboratory was launched from STS-41C in April 1984. It carried 57 exterior-mounted experiments recording the effects of long-term space exposure on construction materials; power cells; optical filters, coatings and glasses, and scientific specimens. LDEF was scheduled to be recovered within the year, but was stranded by program delays and the 1986 Challenger loss. In 1989, increased solar flare activity threatened to speed LDEF's decay, spurring the STS-32 retrieval mission – the last rescue opportunity before the craft's predicted March reentry. LDEF was snagged by shuttle's remote manipulator arm and berthed in the cargo bay on January 12. The facility showed exterior degradation from micrometeoroids, debris, atomic oxygen impingement and ultraviolet rays. Among LDEF's experiments were 12.5 million tomato seeds, flown to determine space effects on living cells. The reclaimed seeds were distributed to 4 million students for classroom experiments. In September, tomatoes grown from one batch of the space seeds took first place at the Kansas State Fair.

Manned Space Flight Records

	Total Flights	Earth Missions	Lunar Missions	Total Crew-hours
United States	68	59	9	51,380
USSR	69	69	–	177,577
Total	**137**	**128**	**9**	**228,957**

Mission durations for 1990 broken down as follows:

TM-8 (from January 1): 49 days, 4 hrs, 36 mn x 2 cosmonauts = 2,361 hrs, 12 mn

TM-9: 179 days, 1 hr, 18 mn x 2 cosmonauts = 8,594 hrs, 36 mn

TM-10: 130 days, 20 hrs, 36 mn x 2 cosmonauts = 6,281 hrs, 12 mn

TM-11 (short visit): 7 days, 21 hrs, 55 mn x 1 cosmonaut = 189 hrs, 55 mn

TM-11 (through December 31): 29 days, 15 hrs, 47 mn x 2 cosmonauts = 1,423 hrs, 34 mns

Total: 18,850 hrs, 29 mn

U.S. Totals:

STS-32: 10 days, 21 hrs x 5 astronauts = 1,305 hrs

STS-36: 4 days, 10 hrs, 18 mn x 5 astronauts = 531 hrs, 30 mn

STS-31: 5 days, 1 hr, 16 mn x 5 astronauts = 606 hrs, 20 mn

STS-41: 4 days, 2 hrs, 10 mn x 5 astronauts = 490 hrs, 50 mn

STS-38: 4 days, 21 hrs, 54 mns x 5 astronauts = 589 hrs, 30 mn

STS-35: 8 days, 23 hrs, 5 mn x 7 astronauts = 1,505 hrs, 35 mns

Total: 5,028 hrs, 45 mn

First manned flight: Vostok 1
First EVA: Voskhod 2
Longest mission: Soyuz TM-4/TM-6 (365 days, 22 hrs, 39 mns)
First rendezvous mission: Gemini 7 and 6
First docking flight: Gemini 8
First lunar orbit: Apollo 8
First crew exchange: Soyuz 4,5
First manned lunar landing: Apollo 11
First triple launch/manned: Soyuz 6,7,8
First use of reusable manned spacecraft: STS 1
First modular space station assembly: Salyut 7/Kosmos 1443
First retrieval, repair of satellite: STS 41-C
First space construction: STS 61-B
First station-to-station crew transfer: Mir/Soyuz T-15 to Salyut 7

Summary Log of Space Launches

The Summary Log lists all known 1990 orbital launches through December 31. Data was compiled from the Goddard Space Flight Center *Satellite Situation Report;* Teledyne Brown Engineering's *The Soviet Year in Space 1990;* The Royal Aerospace Establishment *Table of Artificial Satellites;* United Nations registration documents; The British Interplanetary Society's *Spaceflight;* and public announcements from agencies responsible for project direction. While every effort is made to verify the accuracy of the data, some information varies from source to source and discrepancies may occur.

Launch Date: Universal time

Launch Site:
- ESMC = Eastern Space and Missile Center, Cape Canaveral, FL
- KSC = Kennedy Space Center, FL
- WSMC = Western Space and Missile Center, Vandenberg AFB, CA
- STS = Space Transportation System

Weight: Launch weight in kilograms unless otherwise indicated; Soviet, Chinese weights are approximate

Orbital Data: Initial data for satellites launched and reentered; current for satellites still in orbit (December 31, 1990)

Period: Minutes

Perigee and Apogee: Kilometers

Inclination: Degrees to the equator

Summary Log of Space Launches 1990

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
Skynet 4A	1990 001A	UK	Jan 1	ESMC	Titan III	1,463	1,430.7	34,897	36,462	2.7	British military communications. Stationed above 6 deg. e
JCSat	1990 001B	Japan	Jan 1	ESMC	Titan III	2,280	1,436.2	35,780	35,796	0.0	Japanese domestic communications. Positioned above 154 deg. e
STS-32	1990 002A	US	Jan 9	KSC	Columbia	116,271*	90.8	296	361	28.5	Crew: Daniel Brandenstein, commander; James Wetherbee, pilot; Bonnie Dunbar, Marsha Ivins, David Low, mission specialists. Deployed Leasat 5, retrieved LDEF. Landed 1/20 after 10 days, 21 hrs
Leasat 5	1990 002B	US	Jan 10	STS		7,711	1,436.1	35,774	35,799	3.0	Military communications. Stationed above 177 deg. w
Kosmos 2055	1990 003A	USSR	Jan 17	Plesetsk	A-2	6,300	89.6	251	280	62.8	Photo recon. Reentered 1/29
Kosmos 2056	1990 004A	USSR	Jan 18	Plesetsk	C-1	900	100.7	772	806	74.0	Military communications
SPOT 2	1990 005A	France	Jan 22	Kourou	Ariane 4	1,870	101.3	821	823	98.7	2nd in series of French remote sensing satellites
Uosat 3	1990 005B	UK	Jan 22	Kourou	Ariane 4	45.5	100.8	785	800	98.7	Experimental communications payloads for University of Surrey
Uosat 4	1990 005C	UK	Jan 22	Kourou	Ariane 4	47.5	100.7	786	800	89.7	Test transponders, solar cells, CCD camera for University of Surrey. Communications lost 30 hrs into the mission
Microsat 1	1990 005D	US	Jan 22	Kourou	Ariane 4	12	100.7	784	800	98.7	Amsat amateur radio satellite. Digital message communications. Named Pacsat after launch
Microsat 2	1990 005E	Brazil	Jan 22	Kourou	Ariane 4	12	100.7	784	799	98.7	Amsat amateur radio satellite. Digital Orbiting Voice Encoder (DOVE). Synthesized voice messages received by students with portable receivers
Microsat 3	1990 005F	US	Jan 22	Kourou	Ariane 4	12	100.7	783	800	98.7	Amsat amateur radio satellite. Photographs and transmits earth images. Also called Webersat for Utah's Weber State College, the satellite developer

* Total liftoff weight, 2,049,160 kg.

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
Microsat 4	1990 005G	Argnta	Jan 22	Kourou	Ariane 4	12	100.7	783	800	98.7	Amsat amateur radio satellite. CCD camera for earth photography. Called Lusat after launch
Molniya 3-37	1990 006A	USSR	Jan 23	Plesetsk	A-2-e	1,750	717.6	434	39,912	62.7	Soviet domestic communications
Muses A	1990 007A	Japan	Jan 24	Kagoshima	Mu-3S-II	185	Lunar swingby trajectory				Also called Hiten. Injected lunar orbiter around moon mid-March
Hagoromo	1990 007B	Japan	Mar 19	Muses A		12	Lunar orbit				Lunar orbiter ejected from Muses A for trajectory, telemetry tests. Contact lost after release
GPS 2-6	1990 008A	US	Jan 24	ESMC	Delta 2	1,665	718.0	20,029	20,337	54.6	Global Positioning System
Kosmos 2057	1990 009A	USSR	Jan 25	Plesetsk	A-2	6,500	89.7	195	349	62.8	Photo recon. Reentered 3/19
Kosmos 2058	1990 010A	USSR	Jan 30	Plesetsk	F-2	2,000	97.8	634	665	82.5	Elint
PRC 26	1990 011A	PRC	Feb 4	Xichang	CZ-3	1,024	1,436.1	35,782	35,788	0.1	Domestic communications. Stationed above 98.5 deg. e. Chinese name: Shiyang Tongbu Tonxin Weixing
Kosmos 2059	1990 012A	USSR	Feb 6	Tyuratam	F-2	500	110.0	191	2,276	65.8	Minor military. Reentered 11/12
MOS 1B	1990 013A	Japan	Feb 7	Tanega-shima	H-1	740	103.3	908	909	99.2	Marine observation satellite. Called Momo 1B after launch
Debut	1990 013B	Japan	Feb 7	Tanega-shima	H-1	50	112.2	909	1,742	99.0	Boom/umbrella test. Called Orizuru after launch
JAS 1B	1990 013C	Japan	Feb 7	Tanega-shima	H-1	50	112.2	909	1,742	99.0	Amateur radio satellite. Called Fuji 2 after launch
Soyuz TM-9	1990 014A	USSR	Feb 11	Tyuratam	A-2	7,150	92.5	379	411	51.6	Ferried Anatoli Solovyov and Alexander Balandin to Mir. Docked 2/13. Returned cosmonauts 8/9. Flight time: 179 days, 1 hr, 18 mn
LACE	1990 015A	US	Feb 14	ESMC	Delta 2	1,430	95.2	514	539	43.1	Low-power Atmospheric Compensation Experiment for Strategic Defense Initiative Office (SDIO)
RME	1990 015B	US	Feb 14	ESMC	Delta 2	1,040	93.4	428	456	43.1	Relay Mirror Experiment for SDIO

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
Raduga 25	1990 016A	USSR	Feb 15	Tyuratam	D-1-e	1,965	1,436.0	35,774	35,795	0.7	Domestic communications. Located above 70 deg. e
Superbird/ BS2X		Japan	Feb 22	Kourou	Ariane 4						Launch failure. Blockage in water line decreased thrust in 1st stage motor. Vehicle exploded 100 sec after liftoff
Nadezdha 2	1990 017A	USSR	Feb 27	Plesetsk	C-1	825	104.8	956	1,018	83.0	Navigation. COSPAR/SARSAT transponder
Okean 2	1990 018A	USSR	Feb 28	Plesetsk	F-2	1,900	97.6	632	658	82.5	Oceanographic remote sensing
STS-36	1990 019A	US	Feb 28	KSC	Atlantis		89.4	248	264	62.0	Crew: John Creighton, commander; John Casper, pilot; David Hilmers, Richard Mullane, Pierre Thuot, mission specialists. Deployed one payload. Landed 3/4 after 4 days, 10 hrs, 18 mns
USA 53	1990 019B	US	Feb 28	STS			Elements not available				
Progress M-3	1990 020A	USSR	Feb 28	Tyuratam	A-2	7,250	88.4	277	331	51.6	Resupplied Mir. Docked 3/3. Undocked, reentered 4/28
Intelsat 6 F3	1990 021A	ITSO	Mar 14	ESMC	Titan III	4,215	95.9	552	571	28.3	International communications. 2nd stage separation failure cast it into non-operational orbit
Kosmos 2060	1990 022A	USSR	Mar 14	Tyuratam	F-1-m	4,000	92.7	402	415	65.0	Ocean recon.
Kosmos 2061	1990 023A	USSR	Mar 20	Plesetsk	C-1	825	105.0	970	1,014	82.9	Navigation
Kosmos 2062	1990 024A	USSR	Mar 22	Plesetsk	A-2	6,300	90.6	211	248	82.3	Photo recon. Reentered 4/5
GPS 2-7	1990 025A	US	Mar 26	ESMC	Delta 2	1,665	718.0	20,093	20,271	55.2	Global Positioning System
Kosmos 2063	1990 026A	USSR	Mar 27	Plesetsk	A-2-e	1,900	717.9	812	39,549	63.6	Early warning
Ofeq 2	1990 027A	Isrl	Apr 3	Yavne	Shavit	160	102.5	209	1,577	143.2	Space technology experiments, two-way communications, remote control of systems. Reentered 7/9
Pegsat	1990 028A	US	Apr 5	Pacific	Pegasus	178	95.6	453	645	94.1	Chemical release experiment. First of two payloads deployed by Pegasus launch vehicle dropped from airborne B-52

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
USA 55	1990 028B	US	Apr 5	Pacific	Pegasus	25	96.3	487	661	94.1	Deployed by Pegasus
Kosmos 2064	1990 029A	USSR	Apr 6	Plesetsk	C-1	45	115.4	1,460	1,488	74.0	Tactical communications
Kosmos 2065	1990 029B	USSR	Apr 6	Plesetsk	C-1	45	115.2	1,459	1,473	74.0	Tactical communications
Kosmos 2066	1990 029C	USSR	Apr 6	Plesetsk	C-1	45	114.3	1,384	1,461	74.0	Tactical communications
Kosmos 2067	1990 029D	USSR	Apr 6	Plesetsk	C-1	45	114.4	1,399	1,461	74.0	Tactical communications
Kosmos 2068	1990 029E	USSR	Apr 6	Plesetsk	C-1	45	114.6	1,413	1,461	74.0	Tactical communications
Kosmos 2069	1990 029F	USSR	Apr 6	Plesetsk	C-1	45	114.8	1,427	1,460	74.0	Tactical communications
Kosmos 2070	1990 029G	USSR	Apr 6	Plesetsk	C-1	45	114.9	1,441	1,461	74.0	Tactical communications
Kosmos 2071	1990 029H	USSR	Apr 6	Plesetsk	C-1	45	115.1	1,457	1,460	74.0	Tactical communications
Asiasat 1	1990 030A	UK	Apr 7	Xichang	CZ-3	1,442	1,436.2	35,782	35,795	0.1	1st commercial launch for Chinese. Telecommunications satellite located above 105 deg. e. Formerly Westar 6, retrieved by STS-51A, 1984
USA 56	1990 031A	US	Apr 11	WSMC	Atlas E		Elements not available				
USA 57	1990 031B	US	Apr 11	WSMC	Atlas E		Elements not available				
USA 58	1990 031C	US	Apr 11	WSMC	Atlas E		Elements not available				
Foton 3	1990 032A	USSR	Apr 11	Plesetsk	A-2	6,200	90.3	213	365	62.8	Soviet and French microgravity experiments. Reentered 4/27
Kosmos 2072	1990 033A	USSR	Apr 13	Tyuratam	A-2	6,300	89.7	235	280	64.8	Photo recon. Reentered 11/21
Palapa B-2R	1990 034A	Indo	Apr 13	ESMC	Delta 2	1,200	1,436.3	35,786	35,793	0.0	Refurbished Palapa B2 retrieved by STS-51A. Indonesian communications, stationed above 107.7 deg. e
Kosmos 2073	1990 035A	USSR	Apr 17	Plesetsk	A-2	6,300	88.6	173	239	82.4	Photo recon. Reentered 4/28
Kosmos 2074	1990 036A	USSR	Apr 20	Plesetsk	C-1	825	104.8	964	1,002	82.9	Navigation

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
STS-31	1990 037A	US	Apr 24	KSC	Discovery	117,430*	97.0	610	619	28.5	Crew: Loren Shriver, commander; Charles Bolden, pilot; Bruce McCandless, Steven Hawley, Kathryn Sullivan, mission specialists. Deployed HST. Landed 4/29, after 5 days, 1 hr, 16 mn
HST	1990 037B	US	Apr 25	STS	RMS	10,863	97.0	611	620	28.5	Largest orbiting observatory launched to date. Although flaw in mirror hampered performance, good data returned
Kosmos 2075	1990 038A	USSR	Apr 25	Plesetsk	C-1	1,000	94.0	456	482	74.0	Minor military
Molniya 1-77	1990 039A	USSR	Apr 26	Plesetsk	A-2-e	1,600	717.7	879	39,471	62.8	Domestic communications
Kosmos 2076	1990 040A	USSR	Apr 28	Plesetsk	A-2-e	1,900	717.1	726	39,625	63.2	Early warning
Progress 42	1990 041A	USSR	May 5	Tyuratam	A-2	7,150	92.2	389	403	51.6	Resupplied Mir. Docked 5/7. Undocked, reentered 5/27. Last of original Progress spacecraft
Kosmos 2077	1990 042A	USSR	May 7	Plesotsk	A-2	6,500	89.7	178	377	62.8	Photo recon. Reentered 7/4
Macsat 1	1990 043A	US	May 9	WSMC	Scout	68	98.5	605	765	89.9	Multiple Access Communications. Global store/forward relay for DoD
Macsat 2	1990 043B	US	May 9	WSMC	Scout	68	98.5	605	765	89.9	Multiple Access Communications. Global store/forward relay for DoD
Kosmos 2078	1990 044A	USSR	May 15	Tyuratam	A-2	6,500	89.3	196	280	70.0	Photo recon. Reentered 6/28
Kosmos 2079	1990 045A	USSR	May 19	Tyuratam	D-1-e	1,400	675.7	19,068	19,190	65.0	Glonass navigation system
Kosmos 2080	1990 045B	USSR	May 19	Tyuratam	D-1-e	1,400	675.7	19,111	19,147	65.0	Glonass navigation system
Kosmos 2081	1990 045C	USSR	May 19	Tyuratam	D-1-e	1,400	675.7	19,094	19,164	65.0	Glonass navigation system
Kosmos 2082	1990 046A	USSR	May 22	Tyuratam	SL-16	9,000	101.9	846	852	71.0	Elint
Resurs-F6	1990 047A	USSR	May 29	Plesetsk	A-2	6,300	89.8	255	268	82.3	Remote sensing, German microgravity experiment. Reentered 6/14

*Total liftoff weight, 2,045,895 kg

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
Kristall	1990 048A	USSR	May 31	Tyuratam	D-1	19,640	92.2	377	392	51.6	Materials processing laboratory, permanently affixed to Mir. Docked 6/10
Rosat	1990 049A	FRG	Jun 1	ESMC	Delta 2	2,426	96.1	560	578	53.0	West German X-ray telescope. All sky survey of X-ray and extreme ultraviolet sources
USA 59	1990 050A	US	Jun 8	ESMC	Titan 4		Elements not available				
USA 60	1990 050B	US	Jun 8	ESMC	Titan 4		Elements not available				
USA 61	1990 050C	US	Jun 8	ESMC	Titan 4		Elements not available				
USA 62	1990 050D	US	Jun 8	ESMC	Titan 4		Elements not available				
Insat 1D	1990 051A	India	Jun 12	ESMC	Delta	1,190	1,436.2	35,781	35,795	0.1	Indian domestic communications. Stationed above 83.1 deg. e
Molniya 3-38	1990 052A	USSR	Jun 13	Plesetsk	A-2-e	1,750	717.7	758	39,593	62.9	Domestic communications
Kosmos 2083	1990 053A	USSR	Jun 19	Plesetsk	A-2	6,300	91.4	268	428	82.5	Photo recon. Reentered 7/3
Gorizont 20	1990 054A	USSR	Jun 20	Tyuratam	D-1-e	2,125	1,436.1	35,760	35,813	1.0	Domestic communications. Located above 90 deg. e
Kosmos 2084	1990 055A	USSR	Jun 21	Plesetsk	A-2-e	1,900	98.1	563	770	62.8	Early warning. 4th stage failure. Replaced by Kosmos 2087
Intelsat 6 F4	1990 056A	ITSO	Jun 23	ESMC	Titan III	4,215	1,436.2	35,775	35,800	0.0	International communications. Located above 27.5 deg. w
Meteor 2-19	1990 057A	USSR	Jun 27	Plesetsk	F-2	1,750	104.0	937	961	82.5	Meteorological
Gamma	1990 058A	USSR	Jul 11	Tyuratam	A-2	7,350	92.5	395	398	51.6	Gamma radiation observatory
Badr-1	1990 059A	Pak	Jul 16	Xichang	CZ-2E	52	96.3	201	984	28.4	1st launch of new Chinese booster. Experimental Pakistani payload. Reentered 12/8
Resurs-F7	1990 060A	USSR	Jul 17	Plesetsk	A-2	6,300	88.8	193	276	82.3	Remote sensing. Reentered 8/16
Kosmos 2085	1990 061A	USSR	Jul 18	Tyuratam	D-1-e	2,150	1,436.2	35,762	35,813	1.0	Communications. Stationed over 80 deg. e
Kosmos 2086	1990 062A	USSR	Jul 20	Plesetsk	A-2	6,300	90.3	234	344	82.3	Photo recon. Reentered 8/3

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
TDF-2	1990 063A	France	Jul 24	Kourou	Ariane 4	2,096	1,436.2	35,782	35,793	1.1	French direct broadcast. Positioned above 19 deg. w
DFS-2	1990 063B	FRG	Jul 24	Kourou	Ariane 4	1,418	1,436.1	35,715	35,859	0.0	West German direct broadcast. Stationed above 28.5 deg. e
Kosmos 2087	1990 064A	USSR	Jul 25	Plesetsk	A-2-e	1,900	717.8	924	39,431	62.9	Early warning. Replaced Kosmos 2084
CRRES	1990 065A	US	Jul 25	ESMC	Atlas 1	1,629	591.0	323	33,575	18.2	Combined Release and Radiation Effects Satellite. First commercial launch for Atlas 1
Kosmos 2088	1990 066A	USSR	Jul 30	Plesetsk	F-2	900	116.0	1,481	1,522	73.6	GEO 1K geodetic
Soyuz TM-10	1990 067A	USSR	Aug 1	Tyuratam	A-2	7,150	91.2	312	381	51.6	Carried Gennady Manakov and Gennedy Strekalov to Mir. Docked 8/3. Undocked, returned with cosmonauts 12/10. Flight time: 130 days, 20 hrs, 36 mn
GPS 2-8	1990 068A	US	Aug 2	ESMC	Delta 2	1,665	718.0	19,928	20,436	54.7	Global Positioning System
Kosmos 2089	1990 069A	USSR	Aug 3	Plesetsk	A-2	6,500	89.9	186	357	62.8	Photo recon. Reentered 10/1
Kosmos 2090	1990 070A	USSR	Aug 8	Plesetsk	F-2	225	113.8	1,387	1,411	82.6	New Locsyst communications system. Groups of 6 satellites placed in 4 orbital planes 90 deg. apart
Kosmos 2091	1990 070B	USSR	Aug 8	Plesetsk	F-2	225	114.0	1,409	1,412	82.6	Locsyst communications
Kosmos 2092	1990 070C	USSR	Aug 8	Plesetsk	F-2	225	114.0	1,403	1,412	82.6	Locsyst communications
Kosmos 2093	1990 070D	USSR	Aug 8	Plesetsk	F-2	225	113.9	1,397	1,412	82.6	Locsyst communications
Kosmos 2094	1990 070E	USSR	Aug 8	Plesetsk	F-2	225	113.8	1,392	1,412	82.6	Locsyst communications
Kosmos 2095	1990 070F	USSR	Aug 8	Plesetsk	F-2	225	113.7	1,380	1,412	82.6	Locsyst communications
Molniya 1-78	1990 071A	USSR	Aug 10	Plesetsk	A-2-e	1,600	717.7	648	39,706	62.9	Domestic communications
Progress M-4	1990 072A	USSR	Aug 15	Tyuratam	A-2	7,250	92.1	368	381	51.6	Resupplied Mir. Docked 8/17; undocked 9/17; reentered 9/20
Resurs-F8	1990 073A	USSR	Aug 16	Plesetsk	A-2	6,300	88.5	176	229	82.3	Remote sensing. Reentered 9/1

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
Marcopolo 2	1990 074A	UK	Aug 18	ESMC	Delta 2	1,220	1,436.5	35,717	35,871	0.1	British direct broadcast, second in series. Stationed above 31 deg. w
Kosmos 2096	1990 075A	USSR	Aug 23	Tyuratam	F-I-m	4,000	92.7	402	415	65.0	Ocean recon.
Kosmos 2097	1990 076A	USSR	Aug 28	Plesetsk	A-2-e	1,900	717.5	707	39,630	63.4	Early warning
BS-3A	1990 077A	Japan	Aug 28	Tanega-shima	H-1	1,115	1,436.1	35,782	35,794	0.2	Japanese direct broadcast, located above 110 deg. e. Renamed Yuri 3A after launch
Kosmos 2098	1990 078A	USSR	Aug 28	Plesetsk	C-1	550	108.9	394	1,957	83.0	Minor military
Skynet 4C	1990 079A	UK	Aug 30	Kourou	Ariane 4	1,463	1,436.1	35,771	35,802	3.9	UK defense communications. Placed above 1 deg. w
Eutelsat 2 F1	1990 079B	ESA	Aug 30	Kourou	Ariane 4	1,878	1,382.7	32,556	36,912	0.4	European telecommunications. Located over 13 deg. e
Kosmos 2099	1990 080A	USSR	Aug 31	Plesetsk	A-2	6,300	90.4	244	366	82.3	Photo recon. Reentered 9/14
Fengyun 1-2	1990 081A	PRC	Sep 3	Taiyuan	CZ-4	881	102.8	881	896	99.0	Meteorological
PRC 31	1990 081B	PRC	Sep 3	Taiyuan	CZ-4	4	101.7	775	804	99.0	Atmospheric balloon
PRC 32	1990 081C	PRC	Sep 3	Taiyuan	CZ-4	4	101.9	833	886	99.0	Atmospheric balloon
Resurs-F9	1990 082A	USSR	Sep 7	Plesetsk	A-2	6,300	89.8	267	288	82.5	German microgravity experiment. Reentered 9/21
Kosmos 2100	1990 083A	USSR	Sep 14	Plesetsk	C-1	810	104.8	957	1,011	82.9	Navigation
Molniya 3-39	1990 084A	USSR	Sep 20	Plesetsk	A-2-e	1,750	717.8	625	39,728	62.9	Domestic communications
Progress M-5	1990 085A	USSR	Sep 27	Tyuratam	A-2	2,050	92.3	371	406	51.6	Resupplied Mir. Carried first recoverable capsule to return materials to earth. Docked 9/29. Undocked, reentered 11/28
Meteor 2-20	1990 086A	USSR	Sep 28	Plesetsk	F-2	1,750	104.0	940	958	82.5	Meteorological
Kosmos 2101	1990 087A	USSR	Oct 1	Tyuratam	A-2	6,700	89.1	168	286	64.8	Photo recon. Intentionally destroyed. Reentered 11/30
GPS 2-9	1990 088A	US	Oct 1	ESMC	Delta 2	1,665	718.0	19,859	20,504	54.9	Global Positioning System
Kosmos		USSR	Oct 4	Tyuratam	SL-16						Launch failure. Booster exploded seconds after liftoff

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
PRC-33	1990 089A	PRC	Oct 5	Jiuquan	CZ-2C	2.6 Tons	89.3	199	295	56.9	Biological research. Chinese name: Fanhui Shu Weixing. Capsule recovered 10/13. Bus decayed 10/23
STS-41	1990 090A	US	Oct 6	KSC	Discovery	116,117*	90.2	280	303	28.4	Crew: Richard Richards, commander; Robert Cabana, pilot; Bruce Melnick, William Shepherd, Thomas Akers, mission specialists. Deployed Ulysses. Landed 10/10, after 4 days, 2 hrs, 10 mn
Ulysses	1990 090B	US	Oct 6	STS	IUS	367		Interplanetary trajectory			Enroute to scheduled 2/92 flyby of Jupiter. Gravity will alter trajectory, sending craft on flight path downward from ecliptic plane. Ulysses will end up in solar orbit ranging from 5.4 to 1.3 AU
SBS 6	1990 091A	US	Oct 12	Kourou	Ariane 4	2,478	1,436.0	35,796	35,775	0.0	Commercial communications. Positioned above 99 deg. w
Galaxy 6	1990 091B	US	Oct 12	Kourou	Ariane 4	1,212	1,436.2	35,281	35,796	0.0	Commercial communications. Stationed above 91 deg. w
Kosmos 2102	1990 092A	USSR	Oct 16	Plesetsk	A-2	6,700	89.7	192	360	62.8	Photo recon. Reentered 12/12
Inmarsat 2-1	1990 093A	UK	Oct 30	ESMC	Delta 2	1,385	1,436.3	35,706	35,873	2.3	Mobile communications. Located above 64.5 deg. e
Gorizont 21	1990 094A	USSR	Nov 3	Tyuratam	D-1-e	2,125	1,436.0	35,781	35,788	1.3	Domestic communications. Located above 90 deg. e
USA 65	1990 095A	US	Nov 13	ESMC	Titan 4			Elements not available			
Kosmos 2103	1990 096A	USSR	Nov 14	Tyuratam	F-1-m	4,000	92.7	399	411	65.0	Eorsat. Propulsion system failed mid-January, 91
STS-38	1990 097A	US	Nov 15	KSC	Atlantis		88.6	215	221	28.4	Crew: Richard Covey, commander; Frank Culbertson, pilot; Charles Gamar, Robert Springer, Carl Mead, mission specialists. Reentered 11/20, after 4 days, 21 hrs, 54 mns
USA 67	1990 097B	US	Nov 15	STS				Elements not available			
Kosmos 2104	1990 098A	USSR	Nov 16	Plesetsk	A-2	6,300	90.5	238	361	62.8	Photo recon. Reentered 12/4

* Total liftoff weight, 2,049,816 kg

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
Kosmos 2105	1990 099A	USSR	Nov 20	Plesetsk	A-2-e	1,900	717.7	613	39,737	63.4	Early warning
Satcom C-1	1990 100A	US	Nov 20	Kourou	Ariane 4	1,169	1,436.1	35,771	35,801	0.0	Commercial communications. Stationed above 137 deg. w
GStar 4	1990 100B	US	Nov 20	Kourou	Ariane 4	1,295	1,436.1	35,774	35,798	0.0	Commercial communications. Positioned above 125 deg. w
Molniya 1-79	1990 101A	USSR	Nov 23	Plesetsk	A-2-e	1,600	717.7	584	39,767	62.9	Domestic communications
Gorizont 22	1990 102A	USSR	Nov 23	Tyuratam	D-1-e	1,125	1,435.9	35,762	35,804	1.3	Domestic communications. Placed above 40 deg. e
GPS 2-10	1990 103A	US	Nov 26	ESMC	Delta 2	1,665	718.0	20,072	20,092	54.9	Global positioning system
Kosmos 2106	1990 104A	USSR	Nov 28	Plesetsk	F-2	3,000	95.1	510	533	82.5	Minor military
DMSP	1990 105A	US	Dec 1	WSMC	Atlas E	750	100.6	729	845	98.9	Defense Meteorological Satellite Program. Weather imaging. Operational even though broken nozzle prevented it from reaching desired orbit.
STS-35	1990 106A	US	Dec 2	KSC	Columbia	121,183*	91.7	350	363	28.5	Crew: Vance Brand, commander; Guy Gardner, pilot; Mike Lounge, Robert Parker, Jeffrey Hoffman, mission specialists; Samuel Durrance, Ronald Parise, payload specialists. Hosted Astro-1 astronomy experiment. Returned 12/11 after 8 days, 23 hrs, 5 mns
Soyuz TM-11	1990 107A	USSR	Dec 2	Tyuratam	A-2	7,150	92.2	364	398	51.6	Ferried Viktor Afanasyev, Musa Manarov, Japanese journalist Toyohiro Akiyama to Mir. Docked 12/4. Akiyama returned aboard Soyuz TM-10. His flight time: 7 days, 21 hr, 55 mn
Kosmos 2107	1990 108A	USSR	Dec 4	Tyuratam	F-1-m	4,000	92.7	401	415	65.0	Ocean surveillance
Kosmos 2108	1990 109A	USSR	Dec 4	Plesetsk	A-2	6,700	89.5	181	310	62.8	Photo recon. Reentered 1/26/91
Kosmos 2109	1990 110A	USSR	Dec 8	Tyuratam	D-1-e	1,400	675.7	18,970	19,288	64.8	Glonass navigation system
Kosmos 2110	1990 110B	USSR	Dec 8	Tyuratam	D-1-e	1,400	675.7	19,027	19,231	64.9	Glonass navigation system

* Total liftoff weight, 2,049,009 kg

Name	Int'l Desig.	Proj. Dir.	Launch Data			Weight (kg)	Orbital Data				Status
			Date	Site	Vehicle		Period	Perigee	Apogee	Incl.	
Kosmos 2111	1990 110C	USSR	Dec 8	Tyuratam	D-1-e	1,400	675.7	19,107	19,151	64.8	Glonass navigation system
Kosmos 2112	1990 111A	USSR	Dec 10	Plesetsk	C-1	900	100.6	767	810	74.0	Communications
Raduga 26	1990 112A	USSR	Dec 20	Tyuratam	D-1-e	1,965	1,436.0	35,724	35,846	1.4	Domestic communications. Located above 85 deg. e
Kosmos 2113	1990 113A	USSR	Dec 21	Tyuratam	A-2	7,000	89.6	230	276	64.8	Photo recon
Kosmos 2114	1990 114A	USSR	Dec 22	Plesetsk	F-2	225	114.0	1,407	1,412	82.6	Locsyst communications system. See Kosmos 2090-2095
Kosmos 2115	1990 114B	USSR	Dec 22	Plesetsk	F-2	225	113.9	1,405	1,408	82.6	Locsyst communications system
Kosmos 2116	1990 114C	USSR	Dec 22	Plesetsk	F-2	225	113.9	1,399	1,408	82.6	Locsyst communications system
Kosmos 2117	1990 114D	USSR	Dec 22	Plesetsk	F-2	225	113.8	1,393	1,408	82.6	Locsyst communications system
Kosmos 2118	1990 114E	USSR	Dec 22	Plesetsk	F-2	25	113.8	1,389	1,408	82.6	Locsyst communications system
Kosmos 2119	1990 114F	USSR	Dec 22	Plesetsk	F-2	225	113.7	1,382	1,408	82.6	Locsyst communications system
Kosmos 2120	1990 115A	USSR	Dec 26	Plesetsk	A-2	6,300	90.2	231	336	82.6	Photo recon. Reentered 1/17/91
Raduga 1-2	1990 116A	USSR	Dec 27	Tyuratam	D-1-e	2,000	1,436.3	35,607	35,973	1.5	Domestic communications. Placed above 49 deg. e

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